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An Evaluation Of Lake Erie Shoreline Flood And Erosion Hazard Policy

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AN EVALUATION OF LAKE ERIE SHORELINE FLOOD AND EROSION HAZARD POLICY

by

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ABSTRACT

Shoreline flooding and erosion is a complex problem resulting from the interaction of man and his biophysical environment. More than a century of human encroachment into hazardous Lake Erie shoreline areas has resulted in increasing property damage and government hazard assistance expenditures. This dissertation examines and evaluates policy of the governments of Canada, United States, Ontario, Michigan, Ohio, Pennsylvania and New York for dealing with Erie shoreline flooding and erosion. The involvement of municipal governments in the Erie shoreline hazard problem is also considered.

A four part natural hazard policy evaluation model is developed which seeks to: define the hazard policy problem; identify policy goals and means of achieving these goals; specify environmental, economic, social, political, administrative and technological evaluation criteria; and apply these criteria to a wide range of policies. Data sources used to examine and evaluate Erie shoreline hazard policy include published and unpublished government and other reports, newspapers and statutes. Extensive use has been made of correspondence and interviews with government officials.

The Erie shoreline flood and erosion hazard problem can be defined from a human ecological perspective which stresses the interrelation of human and biophysical elements

and processes. Thus, factors such as lake level fluctuations, beach material composition and nature and extent of human encroachment are important. During the 1972-1975 high water period, some $6,200,000 and $104,000,000 in property damage on the north and south Erie shores, respectively, resulted from the interaction of human and biophysical processes.

Governments attempt to achieve goals of economic efficiency, environmental quality and social well-being by pursuing three broad policy approaches: reducing hazard losses; redistributing hazard losses; and doing nothing. In attempting to reduce hazard losses, governments can modify the hazard cause, modify the hazard and modify the loss potential. Lake level regulation, shore protection works and hazard land use regulation, respectively, are examples. In redistributing hazard losses, governments simply spread the losses among taxpayers generally through disaster relief or other programs. In doing nothing, governments let individuals cope with hazards on their own. Various government agencies at the international, federal, provincial, state and local levels are involved in the Erie shoreline hazard problem. Most agencies exercise a narrow range of means of responding to Erie shoreline hazards.

Government policy has stressed shore protection works and disaster relief. Structural measures such as shore protection works can have important environmental implications. These measures are costly, not always

effective in the long term and encourage continued interaction between human and biophysical processes along the Erie shoreline. Government cost sharing arrangements appear to encourage large scale and inefficient structures. Disaster relief and tax write-offs have been stressed on the south Erie shore and appear to be inefficient in areas of recurring hazard. Government policy has not stressed measures, such as hazard land use regulation, hazard land acquisition and relocation of buildings, which reduce the interaction between human and biophysical processes. Total measurable government hazard expenditures during the 1972-1975 period exceeded $6,800,000 and $58,300,000, respectively, on the north and south Erie shores. Public subsidies to private property owners were 79% and 60% of private property damage, respectively, on the north and south Erie shores.

Shore property damage and government hazard expenditures will continue to increase in the absence of greater emphasis on measures that reduce the loss potential. On the north Erie shore, immediate attention should be given to modifying existing hazard policy. Enforcement of shore protection permits and more extensive application of hazard land use regulation are examples of changes that could be made. In the longer term, consideration should be given to implementing comprehensive coastal zone management so that shoreline flooding and erosion can be viewed in terms of the total range of problems affecting the north Erie shore.

PREFACE

This dissertation stems from the author's involvement in a three year study of land use history and landscape change in the Pelee, Rondeau and Long Point peninsulas on the north Erie shore. This study, directed by Dr. J.G. Nelson and funded by The Canada Council, applied a model for investigating resource management problems which was developed by Dr. Nelson. This human ecological model, which stresses ecology, technology, perceptions and attitudes and strategies and institutional arrangements, has been a most useful organizational framework for various researchers involved in this study.

I wish to extend my sincere thanks to Dr. Nelson for the opportunity to participate in The Canada Council study. As well as providing financial support for part of my dissertation research, this study afforded an opportunity to interact with other researchers, including Dr. J.C. Day, Jim Battin, Don Mann, Jack Fraser and Roger Needham.

Dr. Nelson has been a constant source of inspiration and encouragement throughout the course of my disseration program. Dr. H.A. Hosse and Dr. R.W. Butler contributed to my program of study at the University of Western Ontario and have been particularly helpful since Dr. Nelson's departure to the University of Waterloo. While at Western, I was fortunate to hold a Central Mortgage and Housing Corporation

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A great many individuals and agencies have contributed to this dissertation, particularly through provision of information. However, the four years of study and research related to this disseration would have been impossible to accomplish without the love, understanding and support of my wife, Marilyn. I only hope that in some small way this dissertation can contribute to better understanding and management of Ontario shorelines.

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CHAPTER I

INTRODUCTION

Shorelines are zones of interface between land and water and have great significance from a biophysical and human perspective. Shorelines are subject to physical processes such as water level fluctuations, erosion and deposition. Biologically, shorelines are among the world's most productive ecosystems in terms of biomass production. Some shorelines areas, such as wetlands, are important spawning, nesting, nursery and feeding habitats for fish, waterfowl and other animals. As well, complex physical and biological processes interact in shoreline areas. Water level fluctuations, for example, are important to the maintenance of wetland ecosystems.

Shorelines are also significant from a human perspective. Man has found shorelines attractive locations for residential, industrial, commercial, agricultural and recreational uses. Unfortunately, there is increasing evidence that some human uses of shorelines are not

compatible with biophysical processes. Dredging and land filling destroy wildlife habitat. Residential and industrial uses contaminate water with bacteria, heavy metals and oxygen-robbing nutrients. Some shoreline uses are highly susceptible to damage from natural hazards such as flooding and erosion. Attempts to protect shoreline encroachments from these hazards sometimes result in destruction of the shoreline from a biophysical, recreational and aesthetic viewpoint.

Shoreline flooding and erosion, the focus of this dissertation, is a complex problem resulting from the interaction of man and his biophysical environment. There is evidence in the United States that, in spite of increasing attention and expenditures by individuals and governments, damages from shoreline hazards are increasing.(1). Man's ignorance or neglect of important biophysical processes and his increasing encroachment into dynamic shore areas appear to account for much of this increase in damages. Government policy does not appear to have had much impact in reducing shoreline hazard damages.

This dissertation is directed generally toward the theme of man and hazardous shoreline environments. Specifically, the dissertation examines and evaluates government policy relating to Lake Erie shoreline flooding and erosion.

Research Objectives and Organization

This dissertation is organized around five research objectives.

First, a model for evaluating natural hazard policy, specifically flood and erosion hazard policy on the Lake Erie shoreline, is developed in Chapter II. This four-part model defines the policy problem, identifies policy goals and means of satisfying these goals, specifies evaluation criteria, and applies these criteria to a wide range of policies.

Second, the nature of the Erie shoreline hazard policy problem is defined in Chapter III. A human ecological view of this problem stresses that man and his biophysical environment interact to create the hazard. Lake level fluctuations, physical shoreline characteristics, human encroachment, and human adjustments to hazards will, therefore, be considered as interrelated elements and processes.

Third, federal, provincial, state and local government policy goals and means of satisfying these goals are identified in Chapter IV. While emphasis is on recent expression of policy during the 1972-1975 Lake Erie floods, some consideration is given to an historical perspective.

Fourth, flood and erosion hazard policy relating to the Lake Erie shoreline is evaluated in terms of environmental impact, socio-economic impact, political and administrative

factors, and technological and informational factors. These criteria, developed in Chapter II, are applied to a wide range of policies in Chapter V.

And fifth, the implications of several broad policy approaches to north Erie shoreline hazards are discussed in Chapter VI. Three future scenarios, continuing with existing policy, modifying existing policy, and introducing new policy, are considered.

The term policy is subject to considerable ambiguity. Kerr(1976) notes that policy has been variously defined as "the output of policy-making", "cluster of decision-making", "a pattern of responses", and "a structure or confluence of values and behavior".(2) The Economic Council of Canada(1971), in its report on decision-making, distinguishes between policies, or broad guidelines for action, and programs, or specific tactics.(3) Martin(1975) also distinguishes between policies, or means of achieving ends, and programs and projects, which are more specific manifestations of policies.(4) The distinction appears to be one of degree, as policies, programs and projects are viewed as means of satisfying goals. Moreover, the distinction is not always made. A number of studies, sometimes by inference, consider public policy as simply government action in, or response to, a particular problem area, for example natural hazards.(5)

Policy, as used in this dissertation, refers to the totality of federal, provincial, state and local government

involvement in the Lake Erie shoreline flood and erosion hazard problem. This broad definition includes legislation, regulations, guidelines, incentives, penalties, programs and projects. Also included are administrative factors, that is, the way in which governments are organized to respond to flooding and erosion.(6)

Underlying the dissertation research is the belief that flood and erosion hazards must be considered in their human ecological perspective and that an attempt must be made, however imperfect, to assess the implications of various policies for dealing with these hazards. Government hazard policy has a significant impact on shorelines, both directly through various programs and projects and indirectly through guidelines, regulations, and incentives that greatly influence the adjustments that individual shore property owners make.

At a theoretical level, this thesis demonstrates that a case study of the implications of public hazard policy can increase our general understanding of how man adjusts to his biophysical environment. Existing natural hazard theory suggests that man's perception of the hazard, the theoretical range of adjustments, technological and economic feasibility of the adjustments, and public policy and other social guides affect his choice of particular adjustments to natural hazards. However, previous research has stressed the role of man's perception of hazards and the theoretical range of adjustments, rather than the influence of public

policy. In dealing with the implications of government flood and erosion hazard policy on the Erie shoreline, this thesis sheds light on this latter factor.

At a practical level, this dissertation develops and applies a general model for evaluating natural hazard policy and offers suggestions for improving shoreline hazard policy for Lake Erie. The need for evaluating shoreline flood and erosion hazard policy for Lake Erie is further developed in this Chapter, and the contribution of previous hazard research to the consideration of public policy is outlined.

The Need for Evaluation

O'Riordan(1971) has argued for a policy-oriented approach to resource management and that geographers can "clarify the various issues involved in order to provide a clear basis for public judgement and social action".(7) Other researchers also have stressed the need for greater emphasis on policy and institutional aspects of resource management problems.(8)

Government agencies are increasingly being called upon to justify their policies and considerable thought has been given, in recent years, to evaluative techniques such as benefit-cost analysis.(9) It has become apparent that traditional economic criteria alone, however, are not sufficient bases for decisions, and attention has turned to

social, political and environmental impacts of resource management decisions.

The scale of the flood and erosion hazard problem on Lake Erie and other Great Lakes and the magnitude of government expenditures involved in attempting to reduce and spread the damage costs suggest the need to evaluate current government hazard policy. Flood and erosion damages on the Canadian shores of Lakes Erie, Ontario and Huron from 1972-1973 storms amounted to some $28,000,000.(10) Damages along Michigan's Great Lakes shoreline totalled $54,000,000 during the same period.(11) Moreover, a number of government programs are planned or in progress which will commit large public expenditures to the flood and erosion problem on the Great Lakes and profoundly affect the shore landscape. In Ontario, for example, it is possible that a federal-provincial program might commit $100-200 million over a 20-30 year period for "a permanent and comprehensive system of shore protection on the Great Lakes".(12)

It is desirable, in evaluating policy directed at reducing flood and erosion damages or spreading their costs among a greater number of taxpayers, to pose a number of questions. For example, do shore property owners or the general public pay the greater share of the costs? Are environmental costs associated with particular policies? Do policies encourage continued occupancy of hazardous shoreline areas? These, and other, considerations form a

basis for evaluating government flood and erosion hazard policy.

Natural Hazard Research

Natural hazard research has its theoretical foundation in the concept of human ecology developed by geographers such as Barrows(1923) and defined as "the mutual relations between man and his natural environment".(13) From this foundation, natural hazard researchers have sought to develop theories explaining how man adjusts to risk and uncertainty in natural systems. A model formulated by White(1964) examines the conditions under which flood plain occupants choose among a number of adjustments to the flood problem.(14) Relevant factors are the occupant's perception of the theoretical range of adjustments, his perception of the flood hazard, the technological feasibility of the adjustments, the economic efficiency of the adjustments and social guides.(15) Included in social guides are aspects of public policy such as legislation, regulations, penalties, and incentives.

Hazard researchers purport to examine a number of aspects, including the extent of human occupance of hazard zones, the range of adjustments to hazard, the perception of hazard, the process of adoption of damage-reducing adjustments and the optimal set of adjustments.(16) In actual fact, much hazard research has concerned man's

perception of hazard(17), the range of adjustments to hazard(18) and the process of adoption of adjustments.(19) A very few studies have considered the impact of public policy on individual adjustments to hazard.(20) Still fewer studies have attempted any assessment of the optimal set of adjustments for a particular hazard. A notable exception is White's effort to use benefit-cost criteria to compare the efficiency of protection, emergency action, structural change and flood proofing in relation to bearing the loss.(21) Several economists have since given some consideration to comparing the economic efficiency of several adjustments, notably flood protection and flood plain zoning.(22) Only recently have researchers given thought to other than economic criteria.(23) These studies have stressed the need for a consideration of ecological criteria in flood plain management.

Given the paucity of information on evaluating alternative adjustments to natural hazards, it is instructive to examine procedures developed in other fields, particularly public administration, for evaluating policy. Several such procedures are examined in Chapter II.

Shoreline Hazard Research

Research on shoreline hazards along the U.S. Atlantic coast and elsewhere reveals that flooding and erosion are complex problems resulting from the interaction of

biophysical and human processes and elements. Moreover, man, individually and collectively through all levels of government, generally has displayed a rather poor understanding of these complex problems.

The biophysical aspects of coastal hazards have been a subject of study for some time, and a considerable volume of literature on basic and applied research has emerged.(24) In spite of this literature, there is some doubt that coastal biophysical processes are well understood.(25) Burton, Kates and Snead(1969), for example, suggest several critical gaps in knowledge of natural processes, including transport of beach building sediment along the shore, frequency of coastal storms and other climatological phenomena and impact of storm surge.(26)

The human aspects of coastal hazards have been a more recent concern. Crane(1963), in his study of coastal flooding on Cape Cod, considered both biophysical and human aspects of the hazard problem. He found that residents, while aware of the threat of flooding, purchased or built houses in hazardous locations.(27) More comprehensive studies have attempted to understand how individuals perceive and adopt adjustments to coastal flooding and erosion.(28) Several recent studies go beyond a consideration of individual hazard perception and adoption of adjustments and attempt to understand how local communities respond to coastal hazards.(29) A study by Heikoff(1975), in particular, indicates the influence

institutional arrangements, notably the relations between different levels of government, have on the local adoption of adjustments.(30)

The history of human encroachment onto hazardous shoreline areas along the U.S. Atlantic coast provides numerous examples of man's failure to understand or appreciate coastal processes. Over 30 years of federal experience in managing the barrier islands of North Carolina reveals that attempts to stabilize these dynamic coastal environments may ultimately mean their destruction.(31) It is now apparent that storm overwash is integral to the maintenance of these barrier islands and that only minimal development should be permitted.

Lake Erie Shoreline Hazard Research

Lake Erie flood and erosion hazards have a long history. In April, 1670, the European explorers Dollier and Galinee stopped overnight at Point Pelee on their westward journey along the north Erie shore. A severe northeast storm raised the lake level six feet along the east bar of the Pelee peninsula and carried away some of the provisions of the explorers' party.(32) Since this first recorded flood 'problem', Erie shoreline hazards have been the subject of considerable research and concern.

As early as 1838, the Geological Survey of Ohio documented erosion along the Ohio shoreline of Lake

Erie.(33) In his 1904 address to the Ohio Academy of Science, Moseley provided details of Lake Erie storms as early as 1857 and documented, in some depth, shore erosion on Sandusky Bay.(34) In 1918, Point Pelee was the subject of detailed erosion studies by the Ontario Department of Mines and the Dominion Department of Public Works.(35) In the years following 1945, the U.S. Army Corps of Engineers undertook a number of shore erosion studies along the south Erie shore, particularly in Ohio and Pennsylvania.(36) In Ohio, the Division of Shore Erosion was very active in a research capacity, particularly during the 1950's, under the guidance of the geologist Pincus.(37)

Presently, the Corps of Engineers continues to be an important source of technical knowledge regarding Lake Erie flood and erosion hazards. On the north Erie shore, personnel of Fisheries and Environment Canada's Centre for Inland Waters are currently very active in research on a number of aspects of the flood and erosion problem. Recent studies have concerned shore erosion, nearshore sedimentation, and the effects of storm surge on Point Pelee.(38)

The University of Western Ontario has been the centre of some non-governmental research on Lake Erie erosion. Zimmer(1965), Quigley and Tutt(1968), and Packer(1971) have undertaken research on bluff stability and recession in the vicinity of Port Bruce, where the Department of Geography established an erosion research station in the 1960's.(39)

In 1971, Pleva and students in the Geography Department studied a variety of Erie shoreline problems including erosion.(40)

In 1974, Nelson initiated a three year study of land use history and landscape change in the Pelee, Rondeau and Long Point peninsulas with the support of The Canada Council. This study has involved research on several aspects of the Erie shoreline hazard problem, including perception of hazard and hazard assistance programs(41), response to the fall 1972 flood(42), role of the print media in disseminating hazard information(43) and this present dissertation. As well, research on land use history and landscape change in the Pelee(44) and Rondeau(45) areas has considered, in part, shoreline hazards.

In addition to research by government agencies and academics, Lake Erie flood and erosion hazards have been a subject of concern by shore property owners and politicians. In the late 1940's, individuals and municipal officials from affected communities along the Great Lakes shoreline organized beach preservation associations, in part, to exert pressure on politicians for assistance in dealing with flood and erosion problems. The Ontario Shore and Beach Preservation Association and the Ohio Beach and Shore Preservation Association are illustrative of this type of organization. More recently, citizen groups such as PLEASE(Please Lower Erie And Stop Erosion), which made presentations at the 1974 hearings of the International

Joint Commission on regulation of Great Lakes water levels, reflect the concern of many shore property owners about flooding and erosion.(46) Politicians, from time to time, have responded to pressure from shore property owners and others and initiated investigations of flood and erosion problems. The Select Committee of the Ontario Legislature which investigated lake levels of the Great Lakes and tabled its report in 1954, is an example of political response to such pressure.(47) Similarily, in 1973, the Prime Minister instructed several federal agencies to investigate the shore erosion problem on the Canadian Great Lakes shoreline and along the St. Lawrence River and to compile available information on this problem as an initial step toward federal action.(48)

The high lake levels, flooding, and erosion on Erie and other Great Lakes during the 1972-1975 period have prompted a variety of actions by agencies at all levels of government. Perhaps the most major research and data collection effort on the Great Lakes in recent years is the Canada-Ontario Great Lakes Shore Damage Survey.(49) This survey, which provides information on shoreline physiography, flood susceptibility, recession and accretion, shore property use, ownership, value and property damages during 1972-1973, is seen as a basis for government policy on shoreland management and hazard adjustment.

Over the years, the Lake Erie flood and erosion hazard problem has been the subject of a good deal of interest by

government agencies, academics and some shore property owners. In spite of this attention and considerable private and public expenditure, this dissertation research reveals that shoreline hazard damages are increasing. This paradox suggests the need to examine and evaluate government policy relating to this problem. To this end, a general hazard policy evaluation model is outlined in Chapter II.

NOTES

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[2]D.H. Kerr, "The Logic of 'Policy' and Successful Policies", Policy Sciences, 7, No. 3 (1976), 351.

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[4]L.R.G. Martin, National Urban Land Policy: A Review and Recommendation (Ottawa: Ministry of State for Urban Affairs, 1975), pp. 5-6.

[5]See, for example, H. Visvader and I. Burton, "Natural Hazards and Hazard Policy in Canada and the United States", in Natural Hazards Local, National, Global, ed. by G.F. White (New York: Oxford University Press, 1974), pp. 219-231; E.L. Jackson, "Impact of Public Policy on Private Response to Hazard" (paper presented to the Ontario Division of the Canadian Association of Geographers, Carleton University, Ottawa, March 8, 1975), pp. 11-12.

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[20] See, for example, Jackson, "Public Policy".

[21] White, Choice of Adjustment, pp. 83-105.

[22] See, for example, R.C. Lind, "Flood Control Alternatives and the Economics of Flood Protection", Water Resources Research, 3, No. 3 (1967), 345-357; W. Whipple, Jr., "Optimizing Investment in Flood Control and Floodplain Zoning", Water Resources Research, 5, No. 4 (1969), 761-766.

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CHAPTER II

A POLICY EVALUATION METHODOLOGY

In this Chapter, an attempt is made to review some policy evaluation literature, particularly as this relates to evaluation in resource and natural hazard management. An attempt is also made to develop a methodology suitable for evaluating hazard policy, specifically Lake Erie shoreline flood and erosion hazard policy.

Before undertaking a review of some of the more relevant literature, it is appropriate to consider the relation of policy evaluation to resource management and planning in general.

Evaluation and Resource Management

Resource management has been defined as the process of decision-making whereby resources are allocated over space and time according to the needs, aspirations and desires of man, within the framework of his technological

inventiveness, his political and social institutions, and his legal and administrative arrangements.(1) In brief, resource management is the process of making decisions about resources and the environment.

Numerous researchers in resource management and the field of planning in general have outlined models of the decision-making process. These models have several common attributes and can be generalized as including: the identification and statement of goals or objectives; the identification of possible means or plans of action to meet these goals or objectives; the selection of a preferred plan of action; the implementation of that plan; and a review or evaluation of the plan in terms of the extent to which it meets the intended goals or objectives. Ideally, evaluation is fed back into the process to effect better solutions. In this respect, researchers have stressed the circular and interrelated nature of planning or decision-making and evaluation.(2)

In reality, however, many government agencies have not undertaken evaluations of their policies. Even when policy evaluations have been conducted, there are important problems in using the results. Internal evaluations by government agencies are often viewed by those outside the agency with skepticism about the objectivity of the evaluation. On the other hand, agencies are sometimes reluctant to accept and incorporate the results of external evaluations, particularly negative ones. These are some of

the problems which will have to be overcome if policy evaluation is to make a substantial contribution to effecting better solutions to resource management and other planning problems.

Approaches to Policy Evaluation

Policy evaluation has been defined as an assessment of the effects of policy on the achievement of goals or objectives.(3) A variety of models for evaluating policy have been developed by researchers, particularly in the field of public administration. Several of these models are summarized below.

One model, developed by Cook and Scioli, Jr.(1972), suggests that policy evaluation consists of three elements: performance; adequacy of performance; and efficiency.(4) Performance is the relation between policy outputs and the impact of the policy or, simply, what the policy does. For example, public acquisition of hazard land for conservation and recreation can effectively reduce future damages. Adequacy of performance is the relation between policy performance and the magnitude of the policy problem. Public acquisition of land may be an effective policy; however, it is doubtful whether the entire Erie shoreline could or should be publicly owned. Public acquisition should, therefore, be compared to alternative policies for reducing flood and erosion damages with a view to determining

relative performance and adequacy of performance, or efficiency.

A second model, proposed by Hartle(1973), suggests evaluation involves four elements: operationally defined goals; specificiation of one or more statistical indicators of the extent to which goals are being met; specification of a full range of alternative policies; and an analysis of the relation between policy changes and changes in statistical goal indicators.(5) In this regard, changes in the number and kind of structures in shoreline areas might serve as a statistical indicator of the extent to which a hazard land zoning policy is reducing the loss potential.

A third model offers a five step policy analysis process whereby: a problem is defined and its magnitude investigated; policy is evaluated in light of determined objectives and criteria; alternative policies are compared; and recommendations are made.(6)

The models briefly described, and statements on evaluation methodology(7), suggest that any policy evaluation should ideally: define the policy problem; identify policy goals and means of satisfying these goals; specify evaluation criteria; and apply the criteria to a wide range of policy alternatives.

The essential problem in evaluation is determining the degree of change actually attributable to the policy. The classical experminental method for dealing with this problem is the pretest-posttest control group design.(8) Before the

introduction of a particular policy, such as hazard land zoning, several municipalities could be selected and the nature and extent of shoreline development measured to provide a baseline. After application of zoning to some of the municipalities, shoreline development could again be measured to determine the degree of change due to the introduction of zoning.

A number of problems concerning experimental design evaluation have been identified. Weiss and Rein(1972) have been particularly critical of the experimental design evaluation of "broad-aim programs" or policies.(9) They discuss several technical issues associated with experimental design, including the difficulty in selecting suitable criteria, the essentially uncontrolled character of most situations, and inconsistent application of treatments or policies. Hazard land zoning, for example, might appear successful in a particular area when in fact decreasing shoreline development might also be due to decreasing demand for cottage lots in that area.

In spite of these difficulties, experimental design might be useful in examining particular policies that have clearly defined goals or objectives and where change can be measured quantitatively in a valid and reliable manner. Another approach to evaluation is possible, however.

White(1969), for example, has performed what is essentially a qualitative evaluation of water resource management in the United States.(10) An analysis of the

character of water resource management decisions is necessary, according to White, to understand the discrepancies between what policies intended to accomplish and what was actually accomplished. White assesses several broad approaches to water resource management in terms of three general criteria: who makes what choices; what is the effect upon the public welfare; and what is the effect upon the natural environment. White admits there are no fully adequate answers to these questions.(11) He suggests, for example, techniques for assessing environmental impacts are not yet well developed.

A qualitative, non-experimental evaluation design has some merit in assessing natural hazard policy. Goals and objectives tend to be ambiguous and ill-defined, and there is a wide variety of theoretically possible plans of action for dealing with natural hazards. Moreover, a qualitative, non-experimental evaluation encourages evaluation in terms of a variety of criteria, not just in terms of criteria suggested by the goals or objectives of a policy. Hazard land zoning, for example, might be evaluated in terms of the extent to which it enhances environmental quality, rather than solely on the basis of the extent to which encroachment onto the shoreline, and subsequently damage potential, is reduced. The use of a broader range of criteria is particularly appropriate in evaluating hazard policy, where goals and objectives are not well defined or explicitly stated. Thus, a more qualitative design for evaluation

satisfies an important point that Hamill(1968) raises about the need to be more normative or prescriptive in evaluation. As he notes, "It seems very unsatisfying to many people to be told simply that a good decision is one that meets the objectives of the decision-maker".(12)

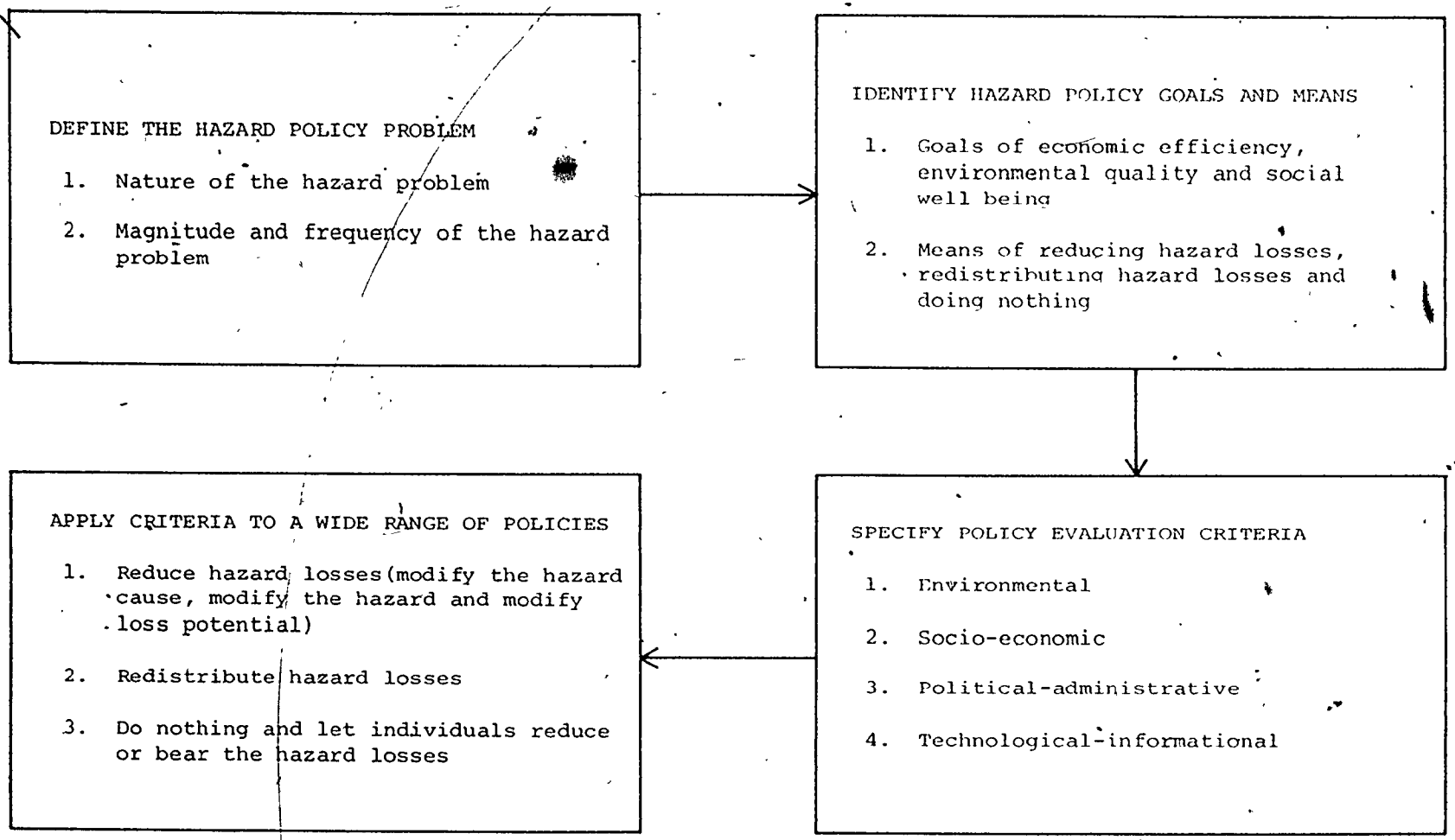
A Hazard Policy Evaluation Model

An evaluation model for assessing natural hazard policy is proposed which, although qualitative and non-experimental in design, satisfies the basic requirements of evaluation as previously outlined. This involves: defining the policy problem; identifying policy goals and means; specifying evaluation criteria; and applying the criteria to a wide range of policy alternatives.

This four-part model is generally applicable to the evaluation of any natural hazard policy. In this dissertation, it is applied specifically to flood and erosion hazard policy on the Lake Erie shoreline. The essentials of the model are summarized on Figure 1.

The policy problem as it relates to Lake Erie flood and erosion hazards is defined in Chapter III. The problem is viewed from the perspective of the human ecology of hazard, that man and nature interact on the Lake Erie shoreline to create the flood and erosion problem. The notion of the human ecology of hazard has been well developed in the hazard literature.(13) In their study of coastal flood

FIGURE 1 HAZARD POLICY EVALUATION MODEL



hazard in the United States, for example, Burton, Kates and Snead(1969) view the hazard as an interaction of natural processes such as littoral drift and storm surge and human processes such as encroachment onto shoreline areas.(14) They stress that an understanding of this intereacting system of human and natural processes is fundamental to any consideration of policy prescriptions.

The policy problem is also defined in Chapter III in terms of the frequency and magnitude of damages from Lake Erie flood and erosion hazards.

Lake Erie shoreline hazard policy goals and means of satisfying these goals are identified in Chapter IV. In brief, government hazard policy has sought to reduce flood and erosion losses and to redistribute these losses among the general public. At times, governments have also pursued a policy of doing nothing, leaving the problem entirely in the hands of individual shore property owners. Although governments often pursue these policies contemporaneously, one or more policies may be emphasized. The present policy goals or objectives relating to the Lake Erie shoreline hazard problem are identified and their historical evolution outlined.

The identification of goals or objectives is often difficult. Broad goals, such as the desire to increase national economic efficiency by reducing hazard damages, or the desire to ease the burden of disaster victims by redistributing hazard losses, are occasionally stated. More

specific objectives, however, may be difficult to define as many programs and legislative enactments lack clearly defined goals or objectives.(15) The Ontario Shoreline Property Assistance Act of 1973, for example, lacks any statement of goals or objectives. Implicit in the Act, however, is the objective of providing any shoreline property owner in the Province with the means for constructing protection works and reconstructing damaged buildings. This represents a significant departure from previous policy which denied cottage owners any assistance whatsoever.

The specification of criteria is perhaps the most critical consideration in any evaluation, quantitative experimental or qualitative non-experimental. Mitchell(1973-1974) notes that there are no rights or wrongs associated with particular criteria, but that the choice of criteria can have considerable influence on the outcome of an evaluation.(16)

Four categories of criteria, or tests of preferredness, will be used to evaluate hazard policy: environmental impact; socio-economic impact; political-administrative factors; and technological informational factors. The final section of this Chapter will be devoted to a consideration of specific criteria within these broad categories.

Using the criteria specified, a wide range of Erie shoreline hazard policies will be evaluated in Chapter V. The policies selected for evaluation are representative of

the range of approaches that have been used to deal with flood and erosion hazards on the Lake Erie shoreline.

Specification of Evaluation Criteria

In this dissertation, Lake Erie flood and erosion hazard policy will be evaluated in terms of four general criteria: environmental impact; socio-economic impact; politicial-administrative factors; and technological-informational factors. It must be recognized, of course, that these criteria are arbitrary and convenient divisions, and that environmental, socio-economic, political-administrative and technological-informational considerations are interrelated. Each criterion is discussed in terms of its appropriateness for evaluating hazard policy, and a number of specific criteria are established.

The first criterion suggests that hazard policy should consider environmental impact. Various flood and erosion hazard policies are, therefore, evaluated in terms of the extent to which they recognize environmental impact. Impact is change, and it is important to understand the consequences of change in the biophysical environment.

The concept of ecology stresses the interrelations and interdependencies of elements and processes.(17) An ecological view of hazard focusses attention on all major interrelated elements and processes at work along the

shore.(18) An understanding of these elements and processes will minimize unanticipated changes in shoreland ecology. An ecological view of hazard might also serve to broaden the range of possible adjustments to flood and erosion hazards. A consideration of environmental impact might reveal, for example, that in some areas maintenance of dune vegetation is preferable to a policy of breakwall construction.

Environmental impact is also appropriate as a criterion for evaluating hazard policy because of an increasing and widespread concern for the biophysical environment. Recent efforts by governments to incorporate environmental considerations into the planning of large scale projects reflects this increasing concern.(19)

Several specific questions can be addressed to any natural hazard policy:

1. Are there impacts on the physical environment? Does shore protection, for example, interfere with sediment movement along the shore, altering the pattern of erosion and deposition?

2. Are there impacts on the biological environment? Is landfilling in wetland areas, for example, occurring?

3. Are there impacts on aesthetics and recreation? Does a breakwall, for example, destroy the view and block recreational access to the shore?

4. Is an environmental impact analysis required or other environmental guidelines specified? Does a policy require a statement of environmental impacts prior to construction of shore protection, for example?

The second general criterion suggests that hazard policy should consider socio-economic impact. In this dissertation, various flood and erosion hazard policies are

considered in terms of the extent to which they consider socio-economic impact.

The need for efficiency in government expenditures has been recognized for some time.(20) In the field of water resource mangement, many government decisions have been made more rational through analysis comparing measurable benefits and costs.(21) There are many examples, however, where benefit-cost analysis has been badly abused as an aid to decision-making and evaluation. Day(1974; 1975) has investigated reservoir projects in Ontario, for example, and shows that costs were underestimated and benefits overestimated.(22)

In addition to efficiency, equity is also an important consideration. Overall, the benefits of a particular policy might exceed costs. However, possible disparities in the distribution of benefits and costs raise social questions. Equity, in economics, refers to fairness and redistribution of income.(23) For cost sharing to be fair, constributions to a project should be in proportion to benefits received. This is not always the case. Recent massive federal-provincial expenditures for construction of dyking on Lake Erie in Kent and Essex counties greatly benefited some farmers, although they paid less than 10% of the total costs. Questions of fairness also arise concerning eligibility for cost sharing. In the Southwestern Ontario dyking projects, for example, only farmers in municipal

drainage schemes were eligible for assistance, while adjacent farmers suffering the same flood problems were not.

Equity also concerns income redistribution, and a number of studies have considered income redistribution as an important criterion.(24) However, income redistribution is socially desirable only in a positive sense, when low income earners benefit. This may not be the case with cost sharing for shore protection, as those benefiting may in fact have average or higher than average incomes.

In the United States, federal cost sharing rules for water resources projects, including flood protection, have been examined by several researchers. Some of this research suggests that differences in cost sharing policies within an agency and among agencies lead to inefficiencies and inequities.(25) Local interests might tend to support policies with the most favourable cost sharing arrangement from their viewpoint, although these policies might not be the most efficient from a national or broader viewpoint.(26)

It is possible to evaluate any natural hazard policy from a broad economic and social perspective by considering the following questions:

5. Are hazard damages reduced? Does a policy actually reduce damage losses, or does it spread these losses among the wider taxpaying public?

6. Is continued occupance of hazard land encouraged? Does a policy, for example, encourage changes in land use to less damage susceptible uses or does it encourage continued or intensified occupance of hazard land?

7. Do hazard land occupants bear most of the costs?

Do the beneficiaries of a policy pay in proportion to the benefits received?

8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified? Does a policy require an assessment of benefits and costs prior to a decision?

The third general criterion suggests that hazard policy should consider certain political and administrative factors. Researchers in water resource management have identified several political and administrative considerations relevant to policy evaluation.

Policy should be politically sensitive.(27) This involves a consideration of acceptability to both hazard land occupants and the general public. Policy should also provide for public input into decisions and adequate appeal procedures for those affected by decisions.(28) The need to accommodate the concerns and objections of those affected by policies has been expressed by the Ontario Committee on Government Productivity(1972).(29) This need has also been recognized by researchers in water resource management.(30)

Another politicial criterion relates to the policy formulation process. Although several models of the policy making process have been developed by political scientists, including the rationalist model(31), the incrementalist model(32) is appealing because it seems to describe the ad hoc nature of government hazard policy making. Lindblom(1972) characterizes government policy making as crisis management, where problems are dealt with as they arise with little attempt to anticipate them. Government

decision-makers "muddle through" a limited number of closely related alternatives in arriving at their decisions, without evaluating the consequences.(33) The model stresses that large disruptive change is not likely to occur, as there is a sequential link with previous policies.

To a certain extent, all policy formulation can be characterized as crisis management in the sense that policies are responses to problems. However, it is possible to distinguish ad hoc, short sighted responses to problems, for example, special disaster relief, from more seriously thought out attempts at solution such as the National Flood Insurance Program in the United States.

The implication of the crisis management nature of policy formulation is that ad hoc, short sighted responses may often be largely ineffective. Emergency shore protection along Lake Erie, for example, was not undertaken until after the disastrous November 1972 flood.

A final political-administrative problem associated with policy concerns jurisdiction. Jurisdiction is used broadly to refer to an agency's constitutional, legal and territorial power to deal with a problem. A number of studies cite jurisdictional limitations as an important factor in evaluating the effectiveness of policy.(34) The fact that an agency can only apply a limited range of policies to a problem can greatly inhibit effective solution of that problem. Federal agencies, for example, are unable

to include direct regulation of land use in their approach to natural hazards.

Several questions concerning political-administrative factors can be applied to a consideration of hazard policy:

9. Is the policy sensitive to the concerns of affected individuals?

10. Is there provision for public input or appeal of decisions? Can objectors to a particular policy, for example, voice their objections at a public meeting or hearing?

11. Is the policy crisis response or ad hoc?

12. Are there jurisdictional or administrative problems in applying the policy?

A final general category of criteria for evaluating hazard policy includes technological and informational factors.

It is desirable that a policy be technologically efficacious, or effective. This requires that a policy be technologically sound and based upon the best information available. White(1969) notes that traditional engineering criteria for efficacy of flood protection structures are safety, workability, durability and economy.(35) The importance of technological efficacy as a criterion in assessing structural or engineering policies for hazard reduction is apparent from the many miles of largely ineffective shore protection that have been built along the Great Lakes and elsewhere, particularly by individual property owners. The United States Department of Army, Corps of Engineers, has conducted considerable research on

the most effective means of shore protection.(36) As well, the Michigan Department of Natural Resources has undertaken a demonstration erosion control program recently to develop effective and economical shore protection works that individual shore property owners can construct.(37)

Technological efficacy does not only apply to structural policies for natural hazards, as it desirable for any policy to be based on the best information available. Improved methods for measuring littoral drift and erosion rates, for example, would be a desirable aid to establishing adequate set-back regulations for buildings along the shore. As another example, some probability functions might be more appropriate than others for estimating the degree of risk of flooding.

It would also be desirable for many policies to make provision for hindsight evaluation of their effectiveness so that experiences gained from application of policy could be fed back to improve policies. The United States Army Corps of Engineers, for example, has recommended procedures for monitoring the success of shore protection structures in the Great Lakes.(39)

From a technological-informational perspective, several questions can be directed to hazard policy:

13. Is the policy technologically efficacious? Is a policy technologically sound?

14. Are there guidelines to ensure technological efficacy? Is an engineering report required, for example, prior to the construction of shore protection works?

15. Is the policy based on adequate information and techniques?

16. Is there provision for hindsight evaluation of the policy?

The criteria listed are by no means exhaustive. Many other criteria could be incorporated into an evaluation of hazard policy. Certain administrative factors such as fiscal and staffing adequacy, have been identified as valid criteria in other studies.(39) Where appropriate, reference is made to these factors in evaluating hazard policy. However, it is believed that the list of criteria specified in this dissertation represents the essential considerations in evaluating hazard policy. The criteria apply to a wide variety of flood and erosion hazard policies and are summarized on Figure 2.

Data Sources

A variety of data sources have been used to examine and evaluate government policy relating to Lake Erie shoreline flooding and erosion. Included are published sources such as newspapers, government and other reports, statutes, regulations and legislative debates. Also included are unpublished reports and government office files. As well, extensive use was made of correspondence and interviews with government officials and other individuals.

FIGURE 2 HAZARD POLICY EVALUATION CRITERIA

ENVIRONMENTAL

1. Are there impacts on the physical environment?
2. Are there impacts on the biological environment?
3. Are there impacts on aesthetics and recreation?
4. Is an environmental impact analysis required or other environmental guidelines specified?

SOCIO-ECONOMIC

5. Are hazard damages reduced?
6. Is continued occupance of hazard land encouraged?
7. Do hazard land occupants bear most of the costs?
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?

POLITICAL-ADMINISTRATIVE

9. Is the policy sensitive to the concerns of affected individuals?
10. Is there provision for public input or appeal of decisions?
11. Is the policy crisis response or ad hoc?
12. Are there jurisdictional or administrative problems in applying the policy?

TECHNOLOGICAL-INFORMATIONAL

13. Is the policy efficacious?
14. Are there guidelines to ensure efficacy?
15. Is the policy based on adequate information and techniques?
16. Is there provision for hindsight evaluation of the policy?

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CHAPTER III

LAKE ERIE FLOOD AND EROSION HAZARDS

This Chapter considers the human ecology of flood and erosion hazards on the Lake Erie shoreline. The biophysical and human nature of Erie shoreline hazards and human response to the these hazards are considered generally for the entire Erie shoreline. The human ecology of shoreline hazards in the Pelee, Rondeau, Long Point and Presque Isle areas is considered in greater detail. As an introduction to this Chapter, the concept of human ecology of hazards is outlined.

The Human Ecology of Hazards

Of fundamental importance to this investigation of Lake Erie flood and erosion hazard policy is a human ecological concept of hazards. This concept, as developed in the natural hazard literature, stresses that a natural hazard is

a function of both biophysical and human elements and processes.(1)

In the context of shoreline flooding and erosion, a human ecological approach requires an understanding of biophysical elements and processes such as lake level fluctuations, beach material composition, wave action, currents, topography and the nature and extent of wetland areas. Such an approach also requires an understanding of human elements and processes such as the nature and extent of human encroachment into shoreline areas and processes of adjustment to shoreline hazards, including shore protection works and nonstructural solutions.

While the interrelatedness of biophysical and human aspects of shoreline hazards cannot be overemphasized, for convenience, these will be discussed separately. An attempt will then be made to reintegrate biophysical and human aspects of the Erie shoreline hazard problem, stressing the magnitude and extent of flood and erosion damages and a more detailed consideration of the human ecology of shoreline hazards in selected areas along the Erie shoreline.

The Biophysical Nature of Erie Shoreline Hazards

Lake Erie is geologically young and very active erosionally. The Lake, in its present form, is less than 5,000 years old.(2) The Erie basin is underlain by thick Palaeozoic sediments in the form of limestone, shales and

sandstones which are exposed only in a few areas in the Western and Eastern Erie Basins. Elsewhere, these sediments are overlain by glacil deposits up to several hundred feet thick. Approximately one-half of the Erie shoreline consists of highly erodible glacial till bluffs up to 120 feet high.(Figure 3)

The remainder of the Erie shoreline is largely composed of marshes and associated peninsulas which were deposited as Lake Erie rose to its present mean elevation of about 570 feet with the rise in the Niagara River outlet due to glacial rebound.(3) The Pelee, Rondeau, Long Point and Presque Isle peninsulas are the largest of these sand spit formations and are highly dynamic systems of beaches, dunes and wetlands.(Figure 4) While the Erie shoreline is subject to processes of flooding, erosion, deposition and wetland formation, among others, only flooding and erosion are dealt with to any extent in this dissertation.

Flooding is inundation of shoreline areas due to fluctuating lake levels. A variety of natural factors influence lake level fluctuations on Lake Erie, including precipitation, evaporation, runoff, groundwater flows, ice retardation and meteorological disturbances.(4) Natural factors of less significance include tides, crustal movement and aquatic growth in the Niagara and Detroit Rivers.(5)

Three types of fluctuations can be distinguished. Long term fluctuations are a result of persistent high or low water supply conditions over a period of several years. For

FIGURE 3 View of the Erie shoreline west of Rondeau, showing an area of highly erodible glacial till bluffs.

FIGURE 4 View of the Pelee sandspit, showing ecologically valuable marsh and the tree-lined sand bar separating the marsh from Lake Erie.

example, several years of above average precipitation have preceded the recent 1972-1975 high water period on Lake Erie and the other Great Lakes. Figure 5 shows annual average elevations for the 1860-1975 period. The long term(1860-1975) average annual level of Lake Erie is 570.5 feet. The highest monthly average elevation, 573.5(June, 1973), and the lowest monthly average elevation, 567.5(February, 1936), yield a long term range of stage for Lake Erie of about 6 feet.(6)

Seasonal fluctuations reflect the annual hydrologic cycle, with higher net supplies in the spring and early summer following the spring runoff. The mean annual range of stage on Lake Erie is 1.5 feet, with a maximum annual range of 2.7 feet and a minimum annual range of .5 feet.(7)

Short term fluctuations, lasting from a few hours to several days, are generated by meteorological disturbances such as storms and changes in atmospheric pressure. Lake Erie, with its long fetch and nearly parallel orientation to prevailing winds, is especially susceptible to short term fluctuations. The maximum instantaneous level of Lake Erie occurred at Buffalo on November 3, 1955. Under strong southwest winds, the level of the lake at Buffalo rose over 8 feet within 6 hours, to a high of 579.1 feet.(8) A seiche, or oscillation, in the lake level followed this storm surge, as the lake sloshed back and forth in reestablishing an equilibrium.(9) Lake Erie is well known for its seiches, which can be caused by changes in

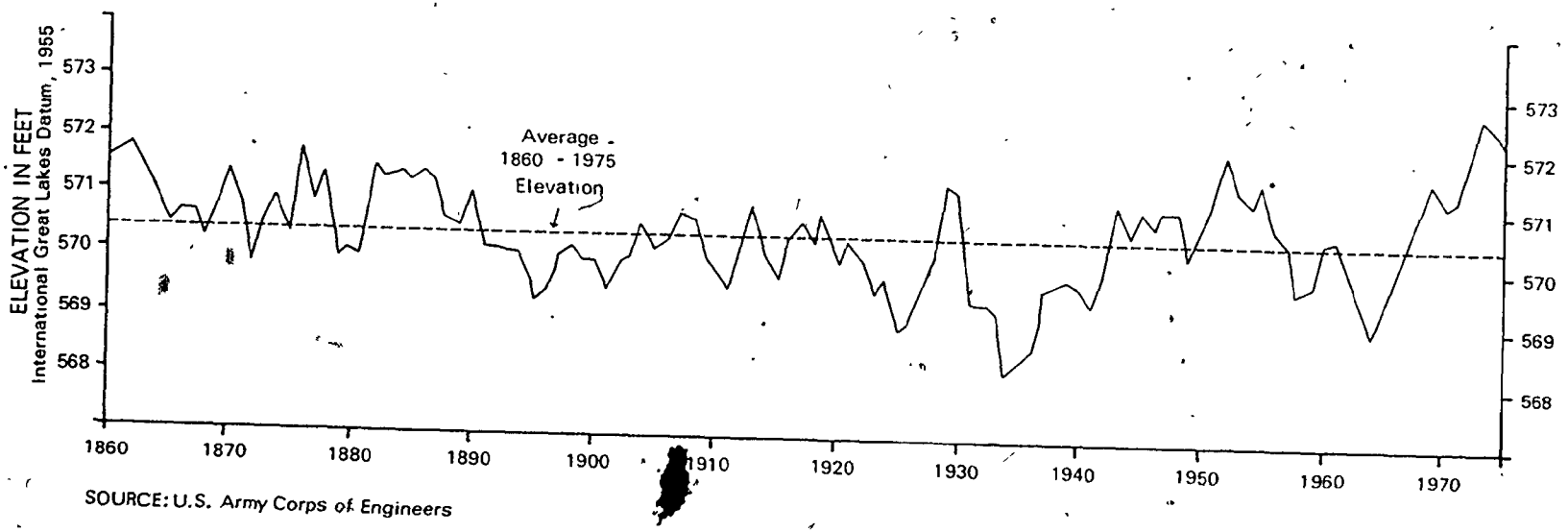


FIGURE 5 LAKE ERIE ANNUAL AVERAGE ELEVATIONS 1860 - 1975

atmospheric pressure as well as storm surges. A low pressure system moving over one end of the lake with a high pressure system over the other end can raise the lake level considerably, even in the absence of wind or wave action.

In addition to these three types of fluctuations, wave action must also be considered, as waves can overtop shore protection works or sandbars. Storms occur on Lake Erie most frequently during the spring and fall. There is a 10% probability of greater than 10 foot waves in March, and a 12% probability in November.(10) There is very little likelihood of significant wave action during the May to August period. An important factor regarding wind and wave action is the air-water temperature difference. Cold air over warm water increases wind speed and wave height.(11)

The potential for flooding is greatest when short term fluctuations are superimposed on longer term fluctuations. Figure 5 shows that periods of longer term high lake levels occur every fifteen or twenty years, for example, 1951-1952 and 1972-1975. Areas of flood susceptibility on Lake Erie include the Pelee, Rondeau, Long Point and Presque Isle sand spits, Monroe County, Michigan and Lucas and Ottawa Counties in Ohio.

Erosion is a natural process occurring to some extent on all shorelines whereby the shoreline adjusts to the forces of erosion.(Figures 6 and 7) Natural factors affecting shore erosion include terrestrial elements such as topography, vegetation and beach material composition;

FIGURE 6 View of the Long Point sandspit, showing an area of shoreline that is undergoing serious erosion. The sand dune upon which this cottage was built has been washed away by storms.

FIGURE 7 Another view of the Long Point sandspit, showing an area of shoreline where accretion is taking place. Cottagers in this area have constructed devices to control sand build up around cottages. These cottages are less than a mile from the one shown in Figure 6, demonstrating the highly variable nature of shore processes.

marine processes including currents; and, atmospheric processes such as wind.(12) As waves and currents attack the shoreline, material is entrained as littoral drift and deposited elsewhere as bars or beaches or lost offshore.(13)

A major variable in shore erosion is the nature of the shoreline material. Glacial deposits are especially susceptible to erosion by rain, wind, groundwater seepage and wave action.(14) Shoreline characteristics for Lake Erie are shown on Table 1 and Figure 8. Erosion is also very much related, like flooding, to the fundamental process of lake level fluctuation. During periods of high water and storm activity, erosion is accelerated in many shoreline areas.(15)

Erosion rates have been documented for many areas of Lake Erie shoreline. On the south Erie shore, areas of particularly severe erosion include Eastlake, Ohio(shore recession 5-20 feet per year) and much of Ashtabula County(shore recession rates of up to 20 feet per year).(16) The Presque Isle sand spit in Pennsylvania is also subject to serious erosion. On the north Erie shore, annual rates of shore recession of 6 inches to 22 feet have been recorded at the University of Western Ontario field station near Port Bruce.(17) Much of the high bluff shoreline of the Central Basin is highly erodible. For example, average annual rates of recession of over 18 feet have been recorded in the Port Burwell area.(18) The Pelee, Rondeau and Long Point sand spits are also subject to serious erosion.

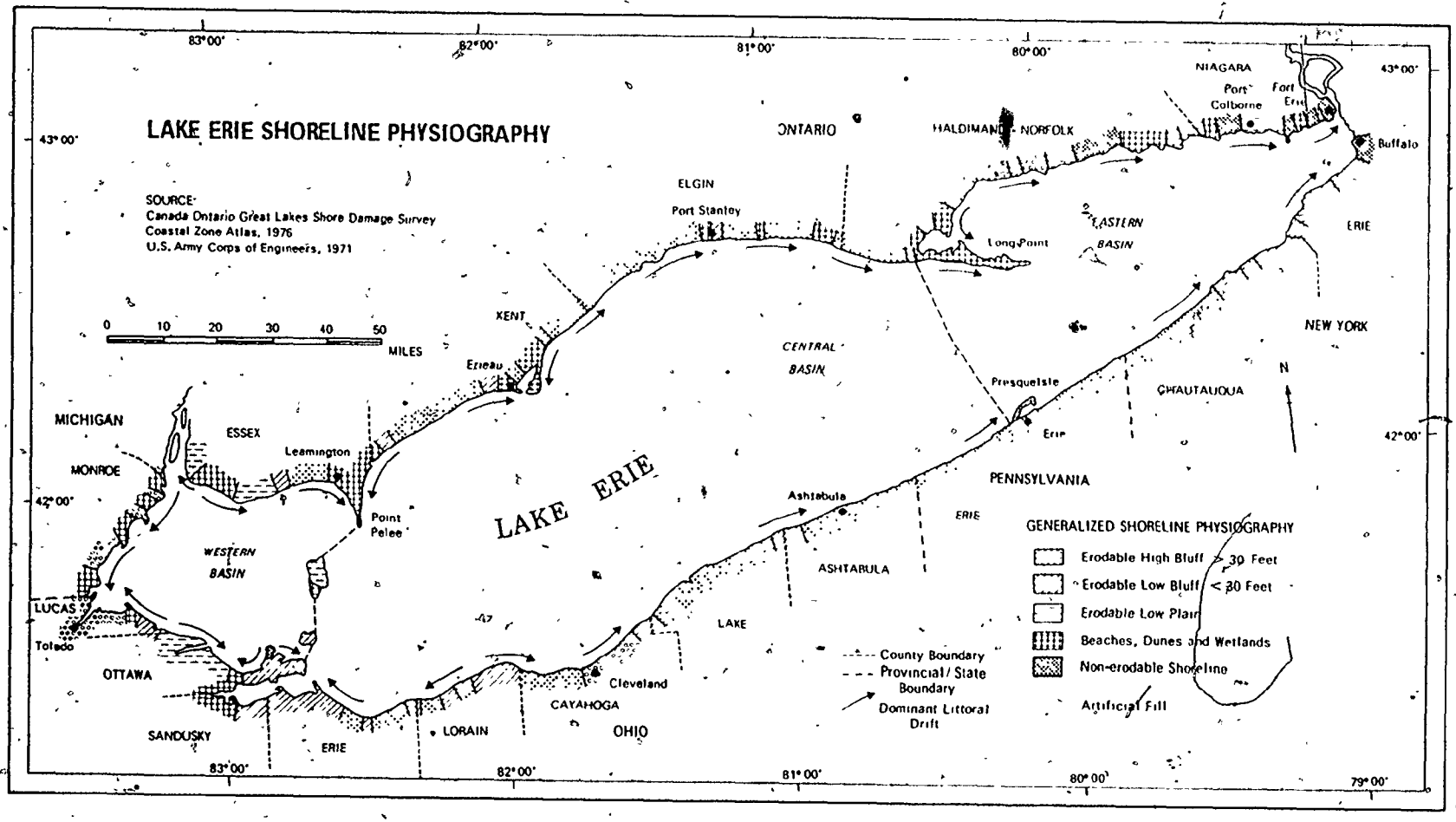
TABLE 1

LAKE ERIE SHORELINE PHYSIOGRAPHY

Shoreline Type	Shoreline Length in Miles (%)					
	North Shore Ontario	South Shore Total	Michigan	Ohio	Pennsylvania	New York
erodible high bluff	121.2(32.0%)	146.4(35.1%)	--	72.7(72.4%)	40.6(84.1%)	33.1(46.7%)
nonerodible high bluff	--	2.0(0.5%)	--	2.0(0.7%)	--	--
erodible low bluff	41.7(11.0%)	81.0(19.4%)	--	55.1(20.8%)	--	25.9(36.5%)
nonerodible low bluff	1.0(0.3%)	73.4(17.6%)	--	72.8(27.5%)	--	0.6(0.8%)
erodible low plain	22.7(6.0%)	28.5(6.8%)	--	19.9(7.5%)	7.7(15.9%)	0.9(1.3%)
nonerodible low plain	3.7(1.0%)	8.8(2.1%)	--	7.5(2.8%)	--	1.3(1.8%)
beaches and dunes	139.1(36.7%)	12.4(2.8%)	--	12.4(4.7%)	--	--
wetlands	41.7(11.0%)	21.9(5.4%)	14.3(44.0%)	7.6(2.9%)	--	--
artificial fill	7.6(2.0%)	42.4(10.2%)	18.2(56.0%)	15.1(5.7%)	--	9.1(12.9%)
total shoreline	378.7(100.0%)	416.8(100.0%)	32.5(100.0%)	265.1(100.0%)	48.3(100.0%)	70.9(100.0%)

Source: Canada-Ontario Great Lakes Shore Damage Survey, Coastal Zone Atlas, 1976; Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix 12: Shore Use and Erosion, 1975.

FIGURE 8 LAKE ERIE SHORELINE PHYSIOGRAPHY



Human Encroachment on the Erie Shoreline

For centuries, man has been attracted to the Erie shoreline for a variety of reasons. Only since the late nineteenth century, however, has significant human encroachment onto the shoreline taken place to the point, where today, some 50% of the entire Erie shore is intensively developed in residential, commercial and industrial uses.

Prior to the coming of Caucasian man, the Indians are known to have utilized the Erie shore for hunting, fishing and some agriculture.(19) Indians appear to have adjusted their camps to lake level fluctuations. Similarly, early Caucasian use of the Erie shore did not create major problems with respect to flood and erosion hazards. Louis Jolliet of Quebec, returning from Lake Superior, is recorded as the first European to see Lake Erie in 1669.(20) He, and subsequent travellers such as Dollier and Galinee, used the north Erie shore as a transportation route. The first permanent settlements in the Lake Erie region were fortified encampments such as Detroit, built by the French in 1701.(21)

Very few settlers moved into the Lake Erie region until after the American Revolution and the War of 1812, when political and territorial considerations stabilized.(22) After the War of 1812, thousands of settlers immigrated to the south Lake Erie shore and ports such as Conneaut,

Vermilion, Lorain and Ashtabula developed at river mouths along the shore.(23) The present larger centres on the south shore, Cleveland, Buffalo and Toledo, were founded in 1796, 1803 and 1807, respectively.(24)

Some settlement occurred on the north Erie shore following the American Revolution. Fort Erie and parts of Welland County(Regional Municipality of Niagara) were first settled in 1784.(25) There was also some early settlement in the Long Point area around 1796(26), but areas further west in Elgin and Kent Counties were not settled until after 1803, when Thomas Talbot secured a large grant of land for settlement purposes.(27) Settlement of the north Erie shore increased after the War of 1812, particularly in port villages such as Port Stanley and Port Burwell. However, encroachment onto the north Erie shore was not as rapid nor extensive as along the south shore. Overton(1970) has suggested that a survey of the north shore from Long Point to Detroit by McNiff in 1790, which reported little opportunity for settlement, may have discouraged encroachment into this area.(28) Larger centres developed inland along rivers and other transportation corridors, rather than along the north Erie shore. Chatham, St. Thomas, London and Brantford were founded in 1800, 1810, 1826, and 1827, respectively.(29)

During the 1800's, much of the north and south Erie shores were cleared for agriculture. With improvements in drainage technology and increasing government assistance,

extensive areas of marsh in Ottawa, Essex and Kent Counties were drained during the period 1888 to 1914, and intensively cultivated.(Figure 9) These areas have a long history of flood and erosion problems and have required considerable effort at shore protection. Presently, some 22% of the north Erie shore is in agricultural use, while less than 22% of the south shore is farmed.(30)

Although some tourist or recreational development took place in the mid-1800's, such as resort development on the Bass Islands in western Lake Erie(31), it was not until the late 1800's and early 1900's that recreational developments, particularly cottaging, became widespread along the Erie shoreline. Cottages in the Rondeau and Fort Erie areas, for example, date back to the 1890's.(32) Since the early 1900's, extensive cottage development has occurred along the north and south shores, most notably in areas of sand beach in the Pelee, Rondeau, Long Point, Fort Erie, Monroe and Sandusky areas.(Figure 10) There are presently over 11,000 cottages on the north shore of Lake Erie.(33) Cottage development has also been extensive along the south shore, but the pressures of urbanization have also been great. Many cottages have been converted to permanent homes. Presently, 41.5% and 42.6% of the north and south Erie shores is developed in permanent and seasonal residential use.

Table 2 summarizes land use and ownership on the Erie shoreline. Figure 11 shows the present distribution of land

FIGURE 9 View of an agricultural drainage scheme at Rondeau, showing productive muck soil. About 1,600 acres of marsh in this scheme were drained and protected from flooding by dykes.

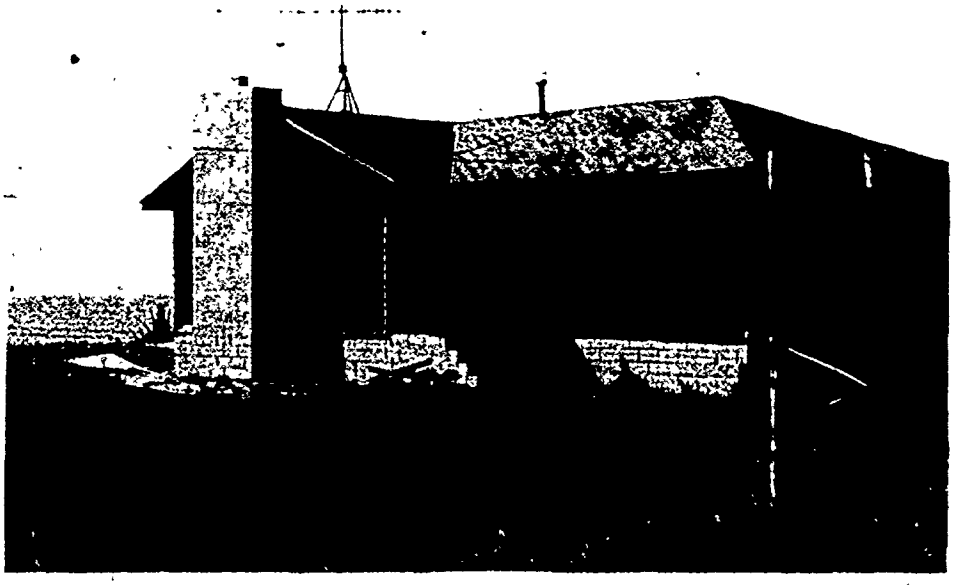


FIGURE 10 View of cottage development near Pelee. Many cottages and homes have been built on the Erie shoreline, apparently with little regard for flooding, erosion and other biophysical processes.

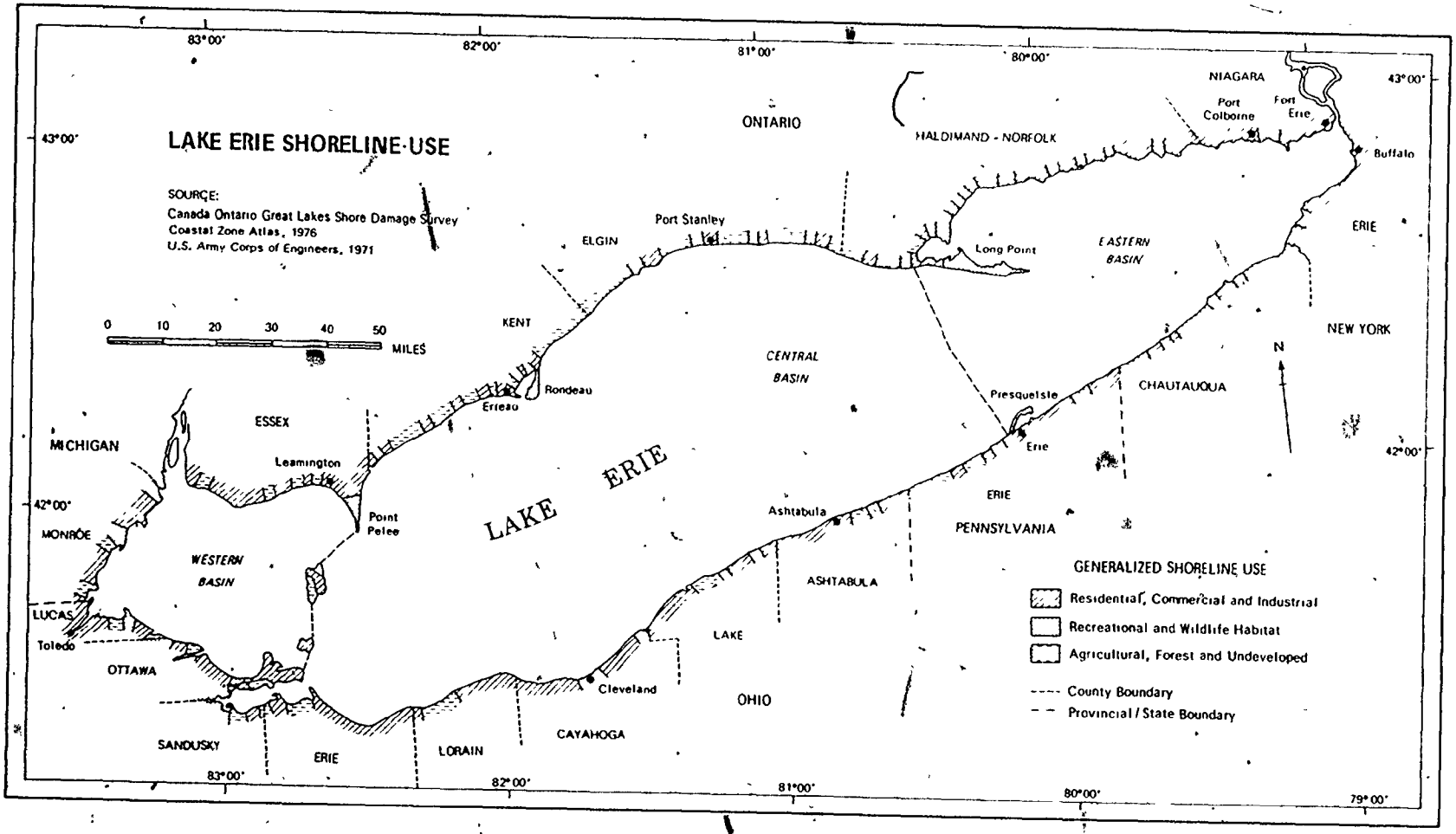
TABLE 2

LAKE ERIE SHORELINE USE AND OWNERSHIP

Shoreline Use	Shoreline Length in Miles (%)					
	North Shore Ontario	South Shore Total	Michigan	Ohio	Pennsylvania	New York
residential	157.2(41.5%)	177.3(42.6%)	15.0(46.2%)	116.4(43.9%)	21.2(43.9%)	24.7(34.9%)
commercial/industrial	8.0(2.1%)	37.2(8.9%)	0.8(2.5%)	23.8(9.0%)	3.6(7.5%)	9.0(12.7%)
agricultural/vacant	138.6(36.6%)	91.8(22.0%)	5.8(17.8%)	49.7(18.7%)	11.9(24.6%)	24.4(34.4%)
parks/other public	56.4(14.9%)	89.3(21.4%)	10.9(33.5%)	58.9(22.2%)	11.6(24.0%)	7.9(11.1%)
other	18.6(4.9%)	21.2(5.1%)	--	16.3(6.2%)	--	4.9(6.9%)
total shoreline	378.8(100.0%)	416.8(100.0%)	32.5(100.0%)	265.1(100.0%)	48.3(100.0%)	70.9(100.0%)
Shoreline Ownership						
federal	18.6(4.9%)	6.1(1.5%)	--	6.1(2.3%)	--	--
other public	37.9(10.0%)	77.8(18.6%)	10.9(33.5%)	42.5(16.0%)	11.6(24.0%)	12.8(18.0%)
private	322.3(85.1%)	332.9(79.9%)	21.6(66.5%)	216.5(81.7%)	36.7(76.0%)	58.1(82.0%)

Source: Canada-Ontario Great Lakes Shore Damage Survey, Technical Report, 1975; Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix 12: Shore Use and Erosion, 1975.

FIGURE 11 LAKE ERIE SHORELINE USE



use on the Erie shoreline. The south shore is somewhat more intensively developed, particularly in commercial and industrial uses, with only 22% of the shoreline remaining in agricultural and vacant uses compared with 36.6% of the north shore in these uses. Moreover, the Great Lakes Basin Commission has projected past trends and suggests, in the absence of further land use regulation, that all agricultural and vacant land will be converted to more intensive residential, commercial and industrial uses by the year 2,000.(34)

Although similar information is not available for the north shore, evidence suggests that conversion of agricultural and vacant land to more intensive uses is a significant process as well. On the north Erie shore, from 1966 to 1973, agricultural and vacant land decreased from 53.1% to 36.6%, while residential use increased from 29.6% to 41.5% of the shoreline.(35)

The Human Ecology of Erie Shoreline Hazards

The interaction of biophysical and human processes and elements, that is, the biophysical nature of flooding and erosion and human encroachment onto shoreline areas, is dramatically illustrated by the magnitude and distribution of property damage.

Table 3 shows property damage occurring on the Erie shoreline during the 1972-1975 period. Detailed data for

TABLE 3

LAKE ERIE SHORELINE FLOOD AND EROSION HAZARD DAMAGES

	North Shore Ontario	South Shore Total	Michigan	Ohio	Pennsylvania	New York
May 1951-April 1952*	n.a.	$39,693,000	$7,949,000	$29,677,000	$1,493,000	$574,000
November 1972-November 1973	$4,504,000	85,705,000	34,988,000	50,377,000	260,000	120,000
November 1973-November 1975	1,728,000	16,443,000	8,125,000	6,972,000	2,000,000	1,340,000
November 1972-November 1975	6,232,000	104,142,000	43,113,000	57,309,000	2,260,000	1,460,000

* Total flood and erosion damages to private and public property expressed in 1973 dollars using the Engineering News-Record Construction Cost Index(3.33X factor 1952-1973).

Source: Canada-Ontario Great Lakes Shore Damage Survey, Technical Report, 1975; Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix 12: Shore Use and Erosion, 1975; Michigan Department of Natural Resources, Flooding Problems associated with current high levels of the Great Lakes, 1973; W.S. Haras, Canada Centre for Inland Waters, Burlington, Personal Communication, January 7, 1976; R.T. Swist, County of Erie, Buffalo, Personal Communication, February 27, 1976; Erie Daily Times, March 19, 1973; Toledo Blade, November 17, 1972, April 28, 1973, June 19, 1973.

the north Erie shore during the period November 1972 to November 1973 are provided by the Canada-Ontario Great Lakes Shore Damage Survey and indicate that total damages during this one year period were $4,504,000. This includes damages to buildings, shore protection works and personal property. Less accurate information is available on damages during the November 1973 to November 1975 period. These have been estimated at $1,728,000. A reasonable estimate of total north Erie shore property damages during the 1972-1975 high water period is $6,232,000.

On the south Erie shore, property damage during the November 1972 to November 1973 period was in excess of $85,705,000. Less complete information suggests that damages during the November 1973 to November 1975 period were about $16,443,000. This produces an estimate of total damages during the 1972-1975 high water period of $104,142,000. It should be noted that damage estimates reported in the print media, upon which the estimates in this dissertation are derived in part, are based on various techniques such as simple visual field checks and should be viewed with some caution. A detailed survey of damages on the south Erie shore is currently underway by the U.S. Army Corps of Engineers, but the results will not be available until 1979.(36)

Damages were greatest in the Western Basin of the Lake, particularly in Monroe County, Michigan, Essex County and the western shore of Ohio. Extensive areas of low-lying

farmland were flooded, including 5,000 acres in Ottawa County, Ohio, 3,000 acres in Monroe County, 2,000 acres in Mersea Township and 6,000 acres on Pelee Island.(37) The low lying areas of Rondeau and Long Point also sustained considerable damage, particularly to cottages and homes.(Figure 12) The storms of November 1972, March-April 1973 and June 1973, were strong 'northeasters'. While these storms account for most of the property damage during the 1972-1975 high water period, it should be noted that a severe southwest storm in November 1975 caused considerable damage in the Eastern Basin, with the shoreline between Long Point and Fort Erie sustaining some $500,000 in damage and considerable damage occuring in the New York portion of the Erie shoreline. As well, a northeast storm in April 1974 effected some $1,260,000 damage in Monroe County.

It is instructive to compare damages during the 1972-1973 period with those which occurred during the 1951-1952 high water period. Comparative data is available only for the south shore and is shown on Table 3. Damage figures for 1951-1952 are expressed in 1973 dollars to permit comparison.(38) Total 1951-1952 damages were $39,693,000, compared with 1972-1973 damages in excess of $85,000,000. Damages have doubled, in large part due to increased encroachment into shoreline areas.

In attempting to protect his encroachment onto the Erie shoreline, man has undertaken a variety of largely structural adjustments that seek to control biophysical

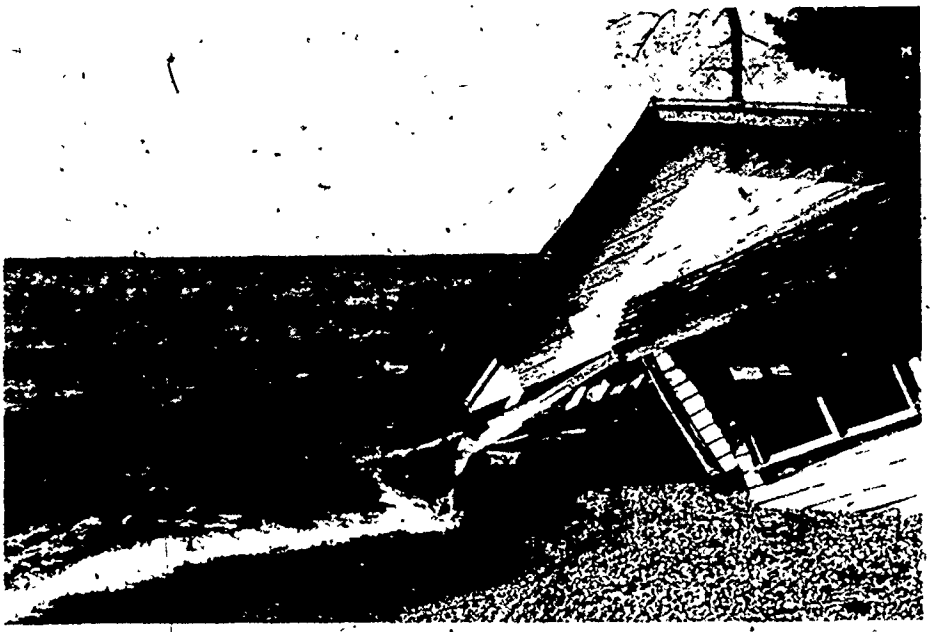


FIGURE 12 View of shoreline damage at Rondeau. About 30 cottages in the Erie Beach area were destroyed by the fall 1972 and spring 1973 storms.

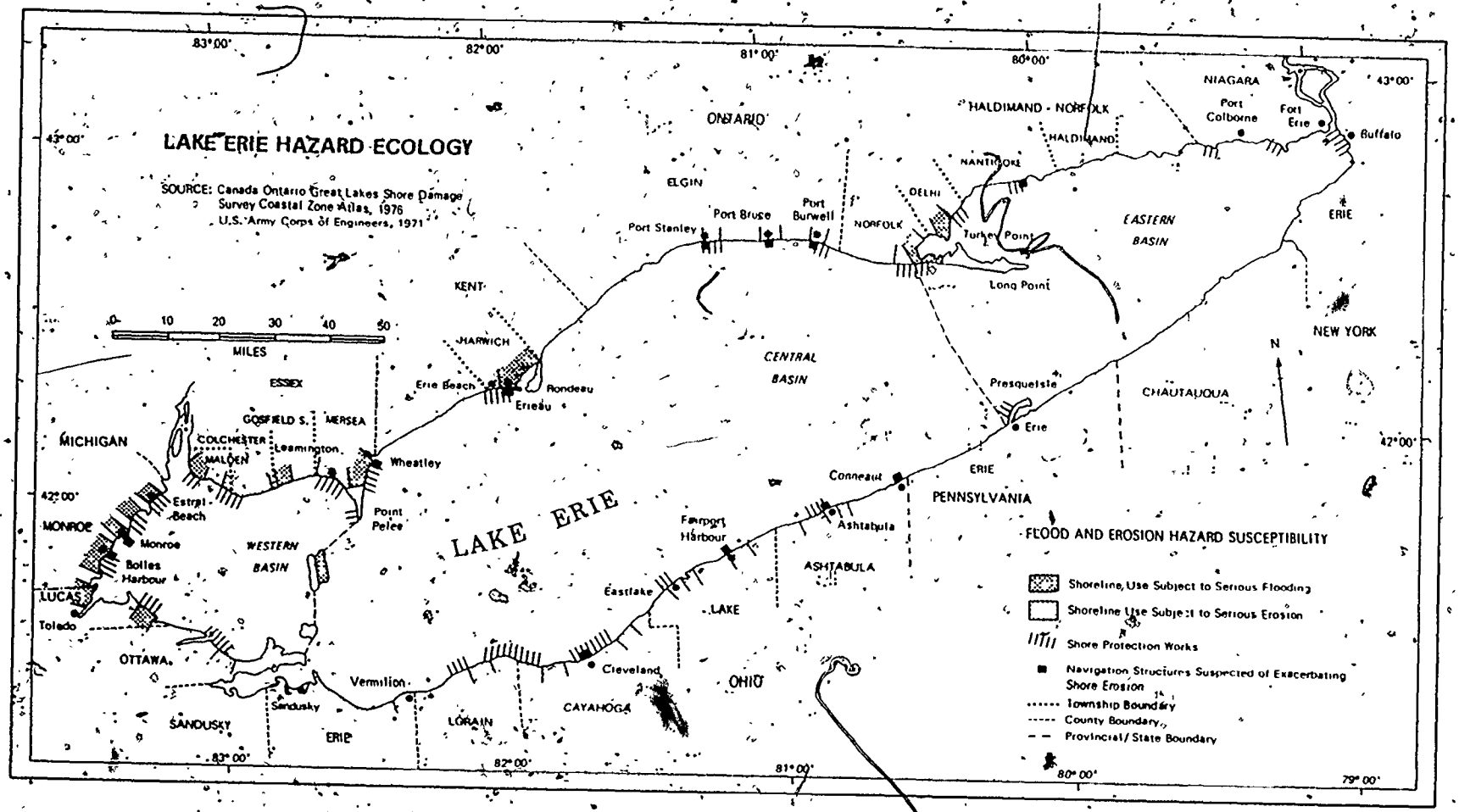
FIGURE 13 View of the Erie shoreline at Port Stanley, showing an area where erosion has been exacerbated by federal piers which interfere with the longshore movement of beach building sediment.

processes such as shoreline sediment movement. Some 10.5% and 35.5% of the north and south Erie shores, respectively, have been protected from flooding and erosion by structural measures such as dykes, seawalls, groynes and breakwaters.(39) More detailed data are available on the variety of measures adopted on the north shore. The most predominant form of shoreline protection are bulkheads and seawalls, and some $1,873,622 was expended by individual shore property owners along the north Erie shore on shore protection works during the November 1972 to November 1973 period.(40)

Man's presence on the Erie shoreline has also affected flood and erosion hazards in other ways. Lake levels, for example, have been influenced by dredging in the Detroit and Niagara Rivers, construction of the Welland Canal and diversion of Arctic waters into Lake Superior.(41) Consumption of lake water for domestic and industrial uses also affects the level of the Lake.(42) Patterns of erosion and deposition are also influenced by man. The protection of numerous harbours by jetties has accelerated erosion on downdrift areas.(43)(Figure 13) Groynes and other shore protection works can also exacerbate erosion in adjacent areas.

The interaction of biophysical and human processes, including areas where man has interacted adversely with erosional processes, is shown on Figure 14.

FIGURE 14 LAKE ERIE HAZARD ECOLOGY



The interaction of biophysical and human processes and elements can also be illustrated by detailed historical examination of these processes in the Point Pelee, Rondeau and Long Point areas. Although these areas were chosen for study as part of a Canada Council project of which hazard adjustment is only a part, they, along with Presque Isle on the south Erie shore, illustrate the implications of human encroachment onto one shoreline physiographic type, the sand spits. The Pelee, Rondeau and Long Point areas have been subjected to various human encroachments including seasonal and permanent residential, agricultural and navigation developments and accounted for 35% of total north Erie shore damages during 1972-1973.(44) While the Presque Isle area has not been intensively developed in residential or other damage prone uses, considerable effort has been expended over the years in an attempt to reduce erosion of its valuable public recreational beaches. As has been noted, intervening bluffs comprise about one-half of the Erie shoreline but these areas have not been studied in detail.

Pelee

The Pelee area is defined here as the Mersea Township shoreline. This 24 mile stretch of Erie shoreline largely consists of low-lying sand beaches and dunes. A good part of the shoreline along the eastern bar is backed by marshes or wetland forests. About 12 miles of Mersea Township shoreline is in public ownership, principally Point Pelee

National Park, which occupies 3,700 acres. An area of shoreline west of Leamington consists of beaches backed by low glacial till bluffs. Much of the Pelee area shoreline is susceptible to flooding, given its low-lying nature. As well, the eastern bar is susceptible to erosion, and the entire sand spit appears to be migrating gradually to the west under the influence of strong currents and wave action from the east.(45)

Over the years, large parts of the Pelee peninsula has been utilized intensively for agriculture and recreation. As well, several harbours have been developed to support fishing and recreation interests.

The first major human encroachment in the Pelee area was the draining of some 5,000 acres of ecologically valuable marsh just north of the federal naval reserve(Point Pelee National Park) in 1894-1895. The drained marshland required dyking along the shoreline and naval reserve property to prevent flooding, and the use of pumps to remove excess water from the scheme. Although the drained marsh has been highly productive from an agricultural viewpoint, continued cultivation of the area has required periodic major expenditures for shore protection against flooding and erosion. Much of the drained marshland has been flooded on three occasions, and some 700 acres of land were abandoned in 1904 because of difficulties in protecting it from flooding. This area was redrained in 1953. A considerable amount of public and private funds have been expended in

maintaining this form of encroachment in the Pelee area. These expenditures are shown in relation to biophysical processes in Table 4. It is important to note that public shore protection expenditures on these drainages schemes have increased considerably through time. It is also important to note that hazard adjustments at Pelee bear a strong relation to natural processes such as storms and periods of high lake levels.

The federal government first became involved in harbour developments in the Pelee area in 1893, when the Leamington dock was purchased by the Department of Public Works. In 1901, a new wharf was constructed to replace the earlier structure. By 1906, it was apparent that the wharf was affecting coastal processes, particularly by trapping sediment on the west side and increasing eroison on the east side.(46) Some modifications were made to the dock to permit passage of some littoral drift, and 3 groynes were later built immediately east of the dock to protect the low bluff. Over the years, dredging and the construction of breakwaters have been necessary to maintain the harbour facilities at Leamington and at Wheatley, where government piers were first constructed in 1912. A recreational harbour was built at Sturgeon Creek on the west bar in 1962. This involved dredging the stream mouth and construction of breakwaters. It is possible that these breakwaters will have some effect on erosion of private property immediately downdrift of the structure. Public expenditures on the

Leamington and Wheatley port facilities in relation to natural processes are also shown on Table 4.

The Pelee area became very popular for cottaging during and after the 1920's. Some private holdings within the National Park were sold for cottage lots in the early 1920's and by 1957 there were an estimated 300 cottages in the Park.(47) With the federal policy of expropriating and acquiring private holdings in the Park, the number of cottages was reduced to 38 by 1972.(48) Outside the Park, cottaging has developed to the point were virtually all the shoreline is occupied in this form of land use. The number of cottages on the west bar has increased from about 24 in 1936 and 134 in 1955, to 235 in 1965.(49) On the east bar, the number of cottages has increased from about 11 in 1941, to 119 in 1955, and to 248 in 1965.(50) Recent encroachment in the Pelee area appears to be mainly along the highly hazardous east bar, in several cottage subdivisions south of Wheatley. To date, problems along the west bar have been limited to contamination of lake water by flooded septic systems.(51) Along the east bar, however, flooding and erosion have been serious problems for cottagers and much of the damages in the Pelee area during the recent high water period were sustained along the east bar. Cottagers have expended considerable funds on shore protection, much of which has been largely ineffective. Private shore protection along the east bar has also contributed to erosion problems along the eastern shoreline of the National

TABLE 4

SHORELINE HAZARD ECOLOGY OF THE PELEE AREA

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1893		petition to drain Pelee marsh		
1894-1895		4,729 ac. of Pelee marsh drained	$22,844	
1899	cave-in	Pelee marsh drainage scheme dykes repaired	1,200	
1901		Leamington wharf constructed	30,679	100% federal
1903	sedimentation	Pelee marsh drains repaired	13,721	
1904	cave-in	700 ac. of Pelee marsh scheme abandoned	4,000	
1904	erosion	sheet piling added to Leamington wharf	3,734	100% federal
1908-1909	seepage	Pelee marsh drainage scheme divided into East and West marsh schemes	26,000	
1909	erosion	groynes built east of Leamington wharf	1,919	100% federal
1910	sedimentation	East and West marsh drains repaired	24,087	
1913		Wheatley wharf constructed	36,787	100% federal
1913	cave-in	West marsh drainage scheme dykes repaired	6,000	
1918		Point Pelee National Park established		
1921	settling	East Marsh drains repaired	10,126	
1922	deposition	west side of Leamington wharf dredged	1,380	100% federal
1922	seepage	Mersea Township assumed responsibility for 535 ac. Lloyd drainage scheme, repaired dykes	10,753	20% provincial
1926	settling	East marsh drains repaired	7,938	
1928	sedimentation	Lloyd drains repaired	10,261	20% provincial

TABLE 4--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1930	flooding	East marsh and Lloyd drainage scheme dykes repaired.	$22,345	20% provincial
1930	sedimentation	West marsh drains repaired	10,869	20% provincial
1930-1934		Leamington wharf reconstructed	174,269	100% federal
1931	erosion	willow poles and wire mesh groynes installed in National Park and adjacent area	10,000	50% federal 50% provincial
1934	low water	Leamington harbour dredged.	23,486	100% federal
1938	seepage	East marsh drainage scheme dykes repaired	10,812	20% provincial
1940	deposition	Leamington harbour dredged	23,641	100% federal
1943	sedimentation	Lloyd drains repaired	15,310	20% provincial
1945	settling	West marsh drains repaired	31,720	20% provincial
1945	poor drainage	Elmdale subdivision drained	2,765	
1949-1951	erosion	oak pilings and concrete crosses installed in National Park	85,000	100% federal
1950	settling	East marsh drains repaired	21,320	20% provincial
1951	deposition	Wheatley breakwater built	76,294	100% federal
1952-1953	flooding	stone breakwall built along East marsh drainage scheme	109,464	50% federal 50% provincial
1953	seepage	East marsh drainage scheme dykes repaired	20,804	20% provincial
1953		650 ac. Marentette drainage scheme established	115,568	20% provincial
1953	high water	sheet steel wave break added to Leamington wharf	51,315	100% federal

TABLE 4--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1954	deposition	Wheatley harbour dredged	$28,148	100% federal
1955		Wheatley breakwater and retaining walls built	106,080	100% federal
1957	settling	East marsh drains repaired	3,927	33-1/3% provincial
1957	deposition	Wheatley harbour dredged	19,956	100% federal
1959		Leamington breakwater constructed	659,506	100% federal
1959	deposition	Wheatley harbour dredged	31,378	100% federal
1959	sedimentation	Lloyd drains repaired	6,589	33-1/3% provincial
1960	deposition	Leamington harbour dredged	151,977	100% federal
1961	deposition	Wheatley harbour dredged	31,378	100% federal
1962	sedimentation	West marsh drains repaired	34,150	33-1/3% provincial
1962	erosion	rock wall built in National Park	36,650	100% federal
1963	low water	Leamington harbour dredged	42,189	100% federal
1964	sedimentation	East marsh drains repaired	15,437	33-1/3% provincial
1964	low water	Wheatley harbour dredged	12,419	100% federal
1964-1965	low water	Leamington harbour dredged	92,489	100% federal
1967	settling	East marsh drains repaired	72,600	33-1/3% federal 33-1/3% provincial
1967	sedimentation	Lloyd drains repaired	19,320	33-1/3% federal 33-1/3% provincial
1967	deposition	Wheatley harbour dredged	87,973	100% federal
1968		Leamington breakwater built	189,722	100% federal

TABLE 4--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1968	settling	West marsh drains repaired	$27,600	33-1/3% provincial
1968-1970	erosion	rock wall built in National Park	77,100	100% federal
1969	erosion	stone breakwall built at Pulley subdivision	200,000	50% federal 40% provincial
1970	erosion	gabion groynes and seawall built at Marentette subdivision	125,000	100% provincial
1971	deposition	Wheatley harbour dredged	24,984	100% federal
1971	high water	drainage system installed at Coterie Park subdivision	19,193	33-1/3% provincial
1972-1973	flooding	stone breakwall built along East marsh drainage scheme	883,111	45% federal 45% provincial
1972-1973	flooding	Lloyd drainage scheme dykes repaired	329,700	45% federal 45% provincial
1972-1973	flooding	Marentette drainage scheme dykes repaired	291,961	45% federal 45% provincial
1974	flooding	clay berm built at Coterie Park subdivision	8,385	33-1/3% provincial
1975	deposition	Wheatley harbour dredged	60,200	100% federal

Source: Canada Department of Public Works, London, unpublished files; Township of Mersea, Leamington, unpublished files.
Dollar values are current(unadjusted) Canadian dollars.

Park, immediately to the south of the cottage area. One large groyne constructed in 1971 appears to be a particular problem.(52)

Erosion has also been a problem for a number years in the National Park, particularly along the eastern shoreline, and western shoreline at the tip of the peninsula. Various types of shore protection works, including oak pilings, concrete crosses and armour stone breakwalls, have been introduced by Park officials in a generally unsuccessful attempt to stop erosion of the Park shoreline.(53)

In summary, it appears that continued human occupance of the Pelee shoreline has required continued and increasing expenditures for shore protection. Public expenditures have been considerable, particularly for the protection of agricultural land. It is probable that the costs of continued occupance in this area, due to flood and erosion hazards, will increase. There are other costs as well, such as agricultural and septic tank pollution, reduced wetland areas and restricted public recreational access to shorelines which may be even more signicant in the long term.

Rondeau

The Rondeau area is defined here as the Harwich Township shoreline, including Rondeau Bay, which totals about 31 miles. Slightly more than half of this shoreline

mileage, 17 miles, is along the Bay. Some 8 miles of Erie shoreline and 7 miles of Rondeau Bay shoreline in Harwich Township are in provincial ownership as Rondeau Provincial Park. Most of the Erie shoreline consists of low sand beaches and dunes, while the Rondeau Bay shoreline is fringed in marsh. Low till bluffs are found along the Erie shoreline in the western portion of the Township, at Erie Beach. The east shore of the Rondeau peninsula, that is, most of the Rondeau Park shoreline on the Lake, is accreting. Most of the west shore, including Erie Beach and the Dyke Road area between Erie Beach and Erieau, is receding. The Rondeau Bay shoreline is particularly susceptible to flooding.

Most of the Erie shoreline in the Rondeau area has been intensively developed in cottaging, particularly at Erieau and Erie Beach. The Rondeau Bay shore, excluding the area of marsh in Rondeau Provincial Park, has been taken up in agricultural and cottage development.

Since the first settlement of the area in 1809(54), most of the area has been cleared for agriculture. Gravity drains running into Rondeau Bay date back to at least 1874. It was not, however, until 1914 that an area of some 1,600 acres of marsh was drained in the southwestern portion of Rondeau Bay. Dykes were constructed to protect the drained marshland from flooding from both the Lake and the Bay, and an embankment was built along the northern perimeter of the scheme to divert runoff from upland area around the drained

farmland. The scheme was flooded by Lake Erie high water in 1919 and 1929. In 1946, several days of heavy rain caused breaching of the northern embankment and flooding by upland runoff. Several smaller drainage schemes were also constructed around Rondeau Bay in years following the initiation of the major Burk drainage scheme. These areas, too, have flooded on various occasions. Private and public expenditures have been considerable over the years in maintaining this schemes, particularly for shore protection. Major expenditures in relation to biophysical processes are shown on Table 5. As with agricultural drainage schemes at Pelee, public shore protection expenditures for the Burk scheme have increased substantially over the years. Hazard adjustments at Rondeau also bear a strong relation to the occurrence of storms and high lake levels.(Table 5)

In the early and mid 1800's, Rondeau Bay was used as a harbour of refuge from storms on Lake Erie. Use of the Bay was often treacherous, however, due to the shifting nature of the entrance to the Bay through the Erieau sand bar. Between 1844 and 1848, the government constructed piers and breakwaters in an attempt to fix the location of the harbour entrance. Storms continued to cut new entrances, requiring lakeshore protection east and west of the piers and almost annual dredging of the harbour entrance. Over the years, the west pier has trapped longshore sediment, accelerating erosion east of the east pier. During the 1972-1975 high water period, the Rondeau Provincial Park shoreline adjacent

TABLE 5

SHORELINE HAZARD ECOLOGY OF THE RONDEAU AREA

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1835	instability of entrance to Rondeau harbour	petition for pier to ensure entrance to Rondeau harbour through Erieau sand bar		
1844-1848		parallel piers built to secure a dredged channel through Erieau sand bar	$74,738	100% federal
1856	strong current undermined Rondeau piers	government survey revealed condition of Rondeau harbour		
1871-1875		Rondeau piers rebuilt and harbour dredged	181,665	100% federal
1877	storm breached Erieau sand bar	government survey revealed sand being carried into Rondeau harbour by storms		
1881		breakwall built to close breach in Erieau sand bar	11,530	100% federal
1894		Rondeau Provincial Park established		
1894	deposition	Rondeau harbour dredged	2,864	100% federal
1901-1903	deposition	Rondeau harbour dredged	5,497	100% federal
1904	deposition	sheet piling added to Rondeau piers	11,646	100% federal
1904-1908	deposition	Rondeau harbour dredged	50,104	100% federal
1912	deposition	Rondeau harbour dredged	30,154	100% federal
1912		Rondeau piers extended	216,940	100% federal
1914		1,600 ac. Burk drainage scheme established	42,531	
1914-1915	erosion	rip-rap placed along lakeshore near Erieau	7,599	100% federal
1915-1917	deposition	Rondeau harbour dredged	5,088	100% federal

TABLE 5--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1918	cave-in	Burk drainage scheme dykes repaired	$20,518	
1918	storm breached Erieau sand bar	rip-rap placed along lakeshore	6,438	100% federal
1919	erosion	2 groynes built east of Rondeau piers	8,261	100% federal
1919	flooding	groynes built along Burk drainage scheme dyke	29,782	20% provincial
1921	poor drainage	Nelles drain built in Shrewsbury	5,369	
1922	erosion	seawall built east of Rondeau piers	15,360	100% federal
1925-1927	deposition	Rondeau harbour dredged	10,861	100% federal
1926	erosion	shore protection built east of Rondeau piers	6,989	100% federal
1929	flooding	seawall and groynes constructed along Burk drainage scheme dyke	105,100	50% federal 20% provincial
1929	deposition	Rondeau harbour dredged	51,778	100% federal
1929	erosion	shore protection built east of Rondeau piers	19,127	100% federal
1930	erosion	40 ac. of Burk drainage scheme abandoned	66,000	20% provincial
1931	erosion	shore protection built east of Rondeau piers	74,962	100% federal
1931	deposition	Rondeau harbour dredged	23,630	100% federal
1934-1940	low water	Rondeau harbour dredged	54,932	100% federal
1934-1940		Rondeau piers reconstructed	127,201	100% federal
1938	erosion	stone breakwall built along Burk dyke	17,740	20% provincial

[59] G. Laidler, "Long Point, Lake Erie: Some Physical and Historical Aspects", Papers and Records, Ontario Historical Society, 36 (1944), 67-68.

[60] C.M. Sokulsky, Environment Canada, Ottawa, Personal Communication, June 7, 1976.

[61] Laidler, "Long Point", pp. 59-63.

[62] H.E. Jephson, Ontario Ministry of Transportation and Communications, London, Personal Communication, September 9, 1976.

[63] D.L. Wilson, "Long Point: Its Historical Geography" (unpublished research paper, University of Western Ontario, Department of Geography, 1975).

[64] Ibid.

[65] Estimate based on air photographs and topographic maps.

[66] F.L. Bishop, "Preference in a Recreational Residential Environment: The Context and Preliminary Findings, Turkey Point, Ontario--A Case Study" (unpublished M.A. research project, University of Water, 1975), p. 31.

[67] Wilson, "Long Point".

[68] Haldimand-Norfolk Lakeshore Study, A Lakeshore Study of Haldimand and Norfolk Counties (n.p., 1973), pp. 98-99.

[69] O.E. Jennings, "Presque Isle's Last Stand", Water, Land and Life, Western Pennsylvania Conservancy, 11, No. 1 (1960), 9.

[70] M.E. Wargo, Presque Isle State Park, Erie, Personal Communication, May 25, 1976.

[71] United States Army Corps of Engineers, Draft Environmental Impact Statement Cooperative Beach Erosion Project at Presque Isle Peninsula, Erie, PA (Buffalo: U.S. Army Engineer District, 1973), pp. 19-21.

[72] Pennsylvania Bureau of State Parks, Presque Isle Yesterday Today Tomorrow (n.p., 1974), p. 1.

[73] Ibid., pp. 1-5.

[74] Ibid.

[75] United States Army Corps of Engineers, Review Report on Cooperative Beach Erosion Control Project at

TABLE 5--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1939	sedimentation	Burk drains repaired	$2,634	
1940-1945	deposition	Rondeau harbour dredged	23,161	100% federal
1942	sedimentation	Burk drains repaired	7,783	
1943	erosion	groynes built along Burk dyke	4,976	
1945	erosion	groynes built along Burk dyke	39,170	20% provincial
1946	erosion	shore protection built east of Rondeau piers	36,041	100% federal
1948	erosion	seawall and groynes built along Burk dyke	32,000	20% provincial
1948	poor drainage	Erie Beach drain built	2,750	
1948-1953	deposition	Rondeau harbour dredged	95,142	100% federal
1948-1953	high water	Rondeau piers repaired	96,577	100% federal
1949	erosion	seawall and groynes built along Burk dyke	48,000	20% provincial
1951	high water	seawall and groynes built along Burk dyke	195,000	50% federal 50% provincial
1952	storms	Burk lakeshore protection repaired	26,005	20% provincial
1953-1954	sedimentation	Burk drains repaired	4,078	33-1/3% provincial
1953	poor drainage	Griffeth Drain built at Shrewsbury	620	
1955	deposition	Rondeau harbour dredged	76,019	100% federal
1955	erosion	Burk lakeshore protection repaired	13,964	33-1/3% provincial
1956-1957	sedimentation	Burk drains repaired	5,413	33-1/3% provincial
1958	erosion	groynes constructed along Burk dyke	16,500	33-1/3% provincial
1960-1961	sedimentation	Burk drains repaired	14,125	33-1/3% provincial

TABLE 5--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1963	deposition	Rondeau harbour dredged	$53,861	100% federal
1963		Rondeau piers repaired	234,391	100% federal
1964-1965	sedimentation	Burk drains repaired	8,278	33-1/3% provincial
1965-1968	low water	Rondeau harbour dredged	79,399	100% federal
1966	sedimentation	Burk drains repaired	3,228	33-1/3% provincial
1969	erosion	seawall and groynes built along Burk dyke	121,899	33-1/3% federal 33-1/3% provincial
1969	high water	Rondeau piers repaired	77,115	100% federal
1969-1974	deposition	Rondeau harbour dredged	70,581	100% federal
1972	erosion	stone rubble placed along Burk dyke	6,500	33-1/3% provincial
1972	storm and high water	Burk drainage scheme farmers petitioned for lakeshore protection		
1973	storms and high water	emergency repairs made to Burk dykes		
1974		Burk dykes reconstructed	1,678,060	45% federal 45% provincial

Source: Canada Department of Public Works, London, unpublished files; Township of Harwich, Blenheim, unpublished files.
Dollar values are current (unadjusted) Canadian dollars.

to the east pier was breached by storms. The Erieau piers, lakeshore protection by cottagers to the west and a commercial sand dredging operation at Port Crewe, some 16 miles to the west, are blamed for the starvation of sediment in the southern portion of the Park.(55) Public expenditures on maintenance of the Rondeau harbour for commercial and recreational purposes are shown on Table 5 in relation to biophysical processes. In addition to the federal harbour at Rondeau, 6 private marinas have been developed on Rondeau Bay.

Since the 1890's, the Rondeau area has been popular from a recreational viewpoint, particularly for cottaging. The railroad was an important initator of cottage development in Erieau and Erie Beach, where the companies leased and sold cottage lots in the 1890's and early 1900's. Until 1918, for example, the railroad was the only land access to Erieau. After 1900, Rondeau Provincial Park became popular for cottage sites as well. In 1909 there were approximately 30 cottages in the Park.(56) The 1920's were particularly active years for cottage development, and by 1928, there were 250 cottages in the Park. Cottage development peaked in 1954, with 459 cottages. After this date, the provincial government instituted a policy of not renewing leases and buying out some cottages.

Outside the Park, the attractive Lake Erie shoreline was first developed in cottages, particularly at Erieau and Erie Beach. Some cottages also appeared along the Dyke

Road, separating the Burk drainage scheme from Lake Erie, during the 1920's. The Erie shoreline was almost completely developed in cottages by the end of the 1950's, with some infilling occurring during the 1960's. During the 1960's some cottage development occurred along the less attractive marsh fringed Rondeau Bay shoreline, concentrated at Shrewsbury and Rondeau Bay Estates. Cottages along Rondeau Bay increased from about 50 in 1950 to 334 in 1973.(57)

Cottage development in the Rondeau area has impacted on the biophysical environment in several respects. Sand dunes have been levelled and marshes land filled. As with cottage development in the Pelee area, contamination of lake water has resulted from ineffective septic systems, especially during periods of high lake levels.(58)

Cottagers and other hazard land occupants in the Rondeau area have expended considerable funds over the years attempting to stabilize the shoreline and protect their properties from flooding and erosion. The Erie shoreline from Erie Beach to Erieau has been particularly susceptible to erosion and flood damages. About 30 cottages in this area were destroyed during the recent high water period.

Long Point

The Long Point area is defined here as the shoreline in the Delhi Township and that part of the Norfolk Township shoreline in the former Township of South Walshingham. This

shoreline is some 74 miles long and includes both the Long Point and Turkey Point sand spits. As a result, much of the shoreline in the Long Point area is low-lying sand beaches and dunes, with some higher dunes on the Long Point peninsula. Extensive areas of marsh are associated with both the Long Point and Turkey Point spits, and much of the spit area is susceptible to flooding during storms and high water periods. About 9 miles of the Long Point area shoreline consists of erodable glacial till bluffs. Of this, 5 miles are located around the Inner Bay between Long Point and Turkey Point, in the Port Rowan area. This bluff shoreline is fringed with a narrow band of marsh, and bluff recession is not very extensive due to the sheltered nature of the Inner Bay. About 4 miles of bluff east of Turkey Point, and one-half mile of bluff west of Long Point are actively eroding. As well, some parts of the sand bars forming the Long Point and Turkey Point spits are susceptible to erosion. This is particularly true of the Hastings Drive area just west of the causeway(Highway 59). An area of sand beach at the east end of Turkey Point, near the bluff, is also eroding. Elsewhere, the shoreline is susceptible to both erosion and deposition depending on the dominant or net forces of coastal processes.

Unlike the Pelee and Rondeau areas, relatively little of the Long Point area shoreline is in public ownership. The provincial government owns several miles of shoreline in Long Point and Turkey Point Provincial Parks, which are 849

and 782 acres in size, respectively. As well, the federal government owns a small parcel of land at the tip of Long Point, in the vicinity of its lighthouse.

Approximately 38 miles of shoreline in the study area, or one-half of the total shore, is under the ownership of of the Long Point Company. This Company; chartered in 1866, purchased virtually the entire Long Point peninsula from the government for $19,000 in 1867, for use as a hunting area.(59) This area has not been developed to any degree. The clubhouse and several cottages and other buildings are built on pilings and are not particularly flood susceptible.

Much of the remaining marsh areas in the Long Point and Turkey Point spits are also in private ownership as hunting areas, and have not been developed. Recently, Environment Canada's Canadian Wildlife Service purchased two areas of marsh from private hunting clubs. The Big Creek and Hahn marshes are 1,450 and 402 acres in size, respectively.(60) As well, the Long Point Region Conservation Authority has acquired 750 acres of marsh for the Port Royal Waterfowl Management Area.

There has been relatively little encroachment into Long Point area marshes, unlike both the Pelee and Rondeau areas. About 100 acres of Turkey Point marsh were drained in 1968 for agricultural purposes. There are no extensive municipal drainage schemes, as at Pelee and Rondeau. Some dredging and land fillinghave occurred in the construction of several marinas, harbour facilities and some cottage developments.

Presently, the federal government maintains small dock facilities at Port Rowan and St. Williams, on the Inner Bay. As well, there are 8 private marinas, all located on the Inner Bay. These marinas and dock facilities associated with some cottages have required dredging and land filling, resulting in some reduction in marsh area. This is particularly true of the Turkey Point marina and an area of cottage development on the marshy Inner Bay side of Long Point, where extensive land filling has been undertaken by cottagers.

Historically, the neck of the Long Point peninsula has been breached by storms and closed by sedimentation on several occasions. Navigation through these passages was often treacherous due to the constantly changing nature of the sand spit. Several times during the 1800's, attempts were made to secure a passage through the neck and maintain a Lake Erie entrance by piers.(61) Since 1906, there has been no passage through the neck.

A summary of biophysical events and human response regarding navigation in the Long Point area is shown on Table 6. Unlike the Pelee and Rondeau areas, with their extensive municipal drainage schemes for agriculture and harbour facilities, public expenditures due to the hazardous nature of the Long Point area have not been extensive. Recently, however, government expenditures have been required to maintain roads in this area, particularly Highway 59 along the neck of the Long Point peninsula.

TABLE 6

SHORELINE HAZARD ECOLOGY OF THE LONG POINT AREA

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1828		petition for navigation channel through Long Point		
1833	Long Point breached by storm	pier built to maintain breach as channel	$3,000	100% federal
1835	severe storm	damaged pier repaired	400	100% federal
1860		Port Royal Ship Canal built through Big Creek marsh		
1865	Long Point breached by storm			
1867		Long Point Company purchased Long Point from federal government		
1893		Port Rowan pier built	8,413	100% federal
1895	Long Point channel closed by deposition			
1901	Long Point channel reopened by storm			
1906	Long Point channel closed by deposition			
1911-1913		Port Rowan pier reconstructed	$7,952	100% federal
1913		St. Williams wharf built	2,511	100% federal
1921		Long Point Provincial Park established		
1928		road access to Long Point established		

TABLE 6--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1930		St. Williams wharf repaired	$5,310	100% federal
1940	deposition	Port Rowan harbour dredged	11,513	100% federal
1948		St. Williams wharf repaired	10,821	100% federal
1950	deposition	Port Rowan harbour dredged	25,668	100% federal
1952		Turkey Point wharf built	17,097	100% federal
1954	Hurricane Hazel damaged Long Point cottages			
1955	deposition	St. Williams harbour dredged	6,677	100% federal
1956	storm	St. Williams wharf repaired	24,162	100% federal
1956	deposition	St. Williams harbour dredged	7,172	100% federal
1958	Long Point cottages damaged by storm			
1959-1960	deposition	Port Rowan harbour dredged	82,572	100% federal
1959		Turkey Point Provincial Park established		
1959		steel breakwater built at Port Rowan	45,578	100% federal
1961		Port Rowan pier repaired	31,689	100% federal
1961	deposition	St. Williams harbour dredged	4,745	100% federal
1965		Turkey Point wharf sold to Province		
1968		100 ac. of Turkey Point marsh drained for agriculture		
1968	deposition	Port Rowan harbour dredged	23,074	100% federal

TABLE 6--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1971-1975	cottages on Long Point Bay flooded			
1973	erosion	shore protection built along Highway 59	$177,253	100% provincial
1973-1974	erosion	Township roads protected with stone breakwalls	118,000	80% provincial
1974	storm	damaged St. Williams wharf removed	4,780	100% federal
1975		Port Rowan pier repaired	24,520	100% federal

Source: Canada Department of Public Works, London, unpublished files; Laidler(1944); Wilson(1975). Dollar values are current(unadjusted) Canadian dollars.

Here, the Ontario Ministry of Transportation and Communications expended over $177,000 in 1973 on shore protection for several hundred feet of highway.(62) Expenditures for road protection in the Long Point area are also shown on Table 6.

The most significant encroachment in the Long Point area has been cottage development. Prior to 1928, only hunting club buildings and several cottages and resorts existed in the Long Point area.(63) After the construction of the causeway(Highway 59) in 1928, which provided the first road access to Long Point, several more cottages were built. By 1940, there were approximately 50 cottages, one permanent home, and two commercial establishments on Long Point. The 1950's and 1960's were very active cottage development years.(64) By 1960, there were 600 cottages and 30 homes on Long Point, and by 1970, there were 900 cottages and 50 homes. Cottage development on the bay side of Long Point has required considerable land filling of wetland areas.

Similarly, cottage development began at Turkey Point in the 1920's and by 1937, there were 49 cottages.(65) This increased to approximately 153 by 1951, and 557 by 1965. In 1975, there were 530 cottages and 134 permanent homes at Turkey Point.(66)

The most recent area of cottage development in the Long Point area is along Hastings Drive, just west of the causeway. About 70 cottages have been built along the sand

bar separating Lake Erie from the Big Creek marsh. The sand bar is exposed to the full force of southwest storms and a number of these cottages have been damaged or destroyed. Various private protection works have not been effective in this area. A storm in January 1971 was particularly damaging, as was the November 1975 storm. Elsewhere, the principal hazard facing cottage and home owners is flooding. A number of cottages in the Long Point Inner Bay area were rendered inaccessible by high lake levels in 1973, and many cottages were closed by health authorities.(67) Contaminated septic systems remain a problem in Long Point and Turkey Point. Recent use has been made of holding tanks and pump out facilities, to permit continued occupance of some cottages and homes. The Haldimand-Norfolk Lakeshore Study(1973) has recommended the relocation of the entire Turkey Point community to an area above the bluff, to eliminate this problem.(68) Some relocation of cottages and homes in the Long Point community and elsewhere along the Haldimand-Norfolk shoreline was also recommended.

The absence of large scale agricultural drainage schemes, typical of the Pelee and Rondeau areas, has reduced considerably public hazard assistance expenditures in the Long Point area. The large proportion of virtually undeveloped shoreline under Long Point Company ownership is also a significant factor in the relatively low public hazard expenditures in this area. Cottage development in the Long Point area has suffered, however, considerable

damages, most of which have been absorbed by individual property owners.

Presque Isle

Presque Isle is defined here as the 3,200 acre Presque Isle State Park, which occupies virtually the entire Presque Isle sand spit. This spit formation on Pennsylvania's Lake Erie shoreline has some 9 miles of sand beach along Lake Erie, and encloses Erie Bay with a marshy shoreline. Maximum elevation of dunes on Presque Isle is about 20 feet above low water datum. The peninsula, the only major sand spit formation along the south Lake Erie shoreline, has been migrating eastward under the influence of strong westerly currents at an estimated rate of 23 feet per year.(69) The neck of the peninsula is eroding while the distal end is accreting. At various times in the past, the peninsula has been breached by storms, transforming the peninsula into an island. Low-lying parts of the peninsula are subject to flooding during high water periods and storms.

The Presque Isle spit has significant scientific and educational importance as it is claimed to be one of the best areas to study the processes of ecological succession in this type of environment.(70) As the end of the peninsula is built up with littoral drift, pioneering plant species take hold and a progression towards climax forest species takes place.(71)

CHAPTER IV

LAKE ERIE FLOOD AND EROSION HAZARD POLICY

This Chapter considers the nature of flood and erosion hazard policy as it relates to the Erie shoreline. An attempt is made to identify hazard policy goals or objectives and means of achieving these goals or objectives. Emphasis is on the present framework of federal, provincial, state and municipal government policies and the expression of these policies during the recent 1972-1975 high water period. Some attention is also given the historical evolution of the present framework of policies. In this respect, it is instructive to consider, first, certain basic models of policy-making and how these relate to the Lake Erie hazards problem. No attempt is made to outline in detail the politics of Erie shoreline hazard policy. For example, relationships among policy-makers including the struggle for budgets and influence and the role of the judiciary in modifying policy are important aspects affecting policy formulation not considered.

protection. A summary of various biophysical events and human responses appears on Table 7.

Since its creation as a park, there has been strong local agitation for shore protection to preserve Presque Isle's popular sand beaches. In 1955, after flooding and severe erosion during the late 1940's and particularly during the 1951-1952 high water period, the state and federal governments signed the first cooperative beach erosion control agreement for Presque Isle.(75). Almost $2,000,000 was expended in 1955-56 for the construction of sheet pile groynes and artificial beach nourishment. This program was not successful, in part because the sand used to nourish the beach was too fine and was lost to coastal processes. A subsequent agreement was signed in 1960 to provide sand placement for a period of 10 years. This program also proved ineffective against storms during the late 1960's and early 1970's, to the point where, in 1973, the federal government had to undertake emergency repairs to protect groynes. A major factor in the Presque Isle erosion problem reportedly is reduced littoral drift due to harbour developments in Ohio, particularly at Conneaut, Fairport and Ashtabula.(76) Jetties and other structures at these harbours are trapping sediment and greatly reducing the supply of beach building sand to Presque Isle.

In recent years, there has been increased local agitation for a more permanent system of shore protection, particularly one which will not require costly maintenance

TABLE 7

SHORELINE HAZARD ECOLOGY OF THE PRESQUE ISLE AREA

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1819-1823		Corps of Engineers surveyed erosion		
1824		Erie harbour established		
1828-1829	peninsula breached by storms	breach closed	$7,390	100% federal
1832-1833	peninsula breached by storms			
1833-1852		navigation channel maintained through breach in neck of peninsula		
1874	peninsula breached by storms	breach closed by plank bulkheads		100% federal
1890		3 stone jetties built along neck of peninsula		100% federal
1917	peninsula breached by storms			
1917-1923		breach closed by rock and sand fill		
1921		Presque Isle State Park established		
1924		paved park road constructed along lakeshore		
1939		pile bulkheads built along lakeshore	44,000	100% state
1941	erosion	local agitation for offshore breakwater		
1943	erosion	rubble mound seawall built	750,000	50% federal 50% state
1947	erosion	State applied for federal erosion project		
1948	erosion	park road relocated		

TABLE 7--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1952	flooding and erosion			
1954-1955		federal beach erosion control project initiated		
1955-1956		sheet pile groynes built and sand fill added	$1,879,126	33-1/3% federal 66-2/3% state
1955	storms	groynes repaired	100,000	100% state
1959	severe storm	sand fill added	24,046	100% state
1960		second federal beach erosion control project initiated		
1960-1961		sand fill added	500,000	33-1/3% federal 66-2/3% state
1963	erosion	groynes repaired with rock fill	54,003	100% state
1964-1965		sand fill added	355,002	70% federal 30% state
1966		groynes repaired with rock fill	165,915	70% federal 30% state
1967	erosion			
1968-1969	severe storm	sand fill added	348,008	70% federal 30% state
1970		Corps of Engineers reviewed beach erosion control project		
1971	erosion	sand fill and nylon sand bags added	534,127	70% federal 30% state
1971-1972	storms	park roads protected with rock fill	40,000	100% state
1972		sand fill and nylon sand bags added	391,021	100% state

TABLE 7--Continued

Date	Natural Activity	Human Activity	Cost	Cost Sharing
1972-1973	storms	rock fill added	$25,000	100% state
1973	storms	sand fill added to protect groynes	248,000	100% federal
1973	erosion	park roads repaired	100,000	100% state
1973	erosion	small offshore breakwater built and roads protected with rip-rap	662,956	100% state
1973		Corps of Engineers review report recommended partial breakwater for entire peninsula at estimated cost of $21,203,000		
1974	erosion	sand fill added	750,000	70% federal 30% state
1975	erosion	sand fill added	750,000	70% federal 30% state

Source: U.S. Army Corps of Engineers, Buffalo, files; Pennsylvania Bureau of State Parks (1974). Dollar values are current (unadjusted) United States dollars.

by state or local interests. Many people view the construction of a full breakwater along the length of the peninsula's lakeside beaches as the only 'permanent' solution.(77) In 1970, the Corps of Engineers undertook a review of previous erosion control programs and issued a report in 1973 recommending a partial breakwater scheme estimated to cost over $21,000,000.(78) There is some concern that this project, if approved, will do irreversible damage to the ecological significance of Presque Isle, as the supply of sediment to the distal end of the peninsula, where ecological succession begins, would be greatly reduced. The environmental impact statement on the proposed project only speculates as to reduction in the rate of sand spit formation.(79)

The proposed project has an assumed economic life of 50 years. It is difficult to say, however, how long the project might last in terms of preventing erosion of the peninsula. Annual maintenance will be required, principally in redistributing sand that accretes behind the partial breakwater to areas of erosion downdrift of the breakwater segments. As well, the structures themselves will not last forever. It is misleading, therefore, to term any solution to the erosion problem at Presque Isle as permanent.

In spite of the absence of hazard susceptible agricultural and cottage development characteristic of the Pelee, Rondeau and Long Point areas, significant public hazard costs have been incurred at Presque Isle in an

attempt to maintain recreational beaches. To date, federal and state expenditures on shore protection at Presque Isle are well over $13,000,000.(80) Furthermore, the state spent $6,000,000 between 1956 and 1973 on improvements such as roads, bath houses, sanitary facilities and a large marina.(81) The federal government has also expended large sums over the years in dredging channels to the harbour and the harbour basin. The proposed partial breakwater, or any other system of shore protection for Presque Isle would add significantly to the long term costs of maintaining the beaches for recreation. This suggests the need to consider a variety of approaches to the erosion problem at Presque Isle, including more cost effective structural solutions such as sandtrap recirculation, as suggested by the Board of Engineers for Rivers and Harbors.(82) There is also the alternative of leaving the sand spit to natural processes. In this respect, the National Parks Service experience in managing North Carolina's barrier islands may have important implications for Presque Isle.(83)

Conclusions

The history of human encroachment and adjustment to coastal hazards in the Pelee, Rondeau, Long Point and Presque Isle areas of Lake Erie suggests the following observations:

First, the human ecology of Erie shoreline hazards has been poorly understood. The natural hazard system has evolved from an interaction of both biophysical and human processes. Coastal processes and the implications of these processes on human activity generally have been ignored or neglected.

Second, man has found shoreline areas attractive for a variety of reasons, notably agriculture, harbour development and seasonal and permanent residential development. Decisions to locate particular encroachments, such as drainage schemes, piers or cottages, do not generally appear to have incorporated information on flooding and erosion, particularly basic data such as lake level fluctuations, the period of record of which dates to 1860. As a result, shore property damages have been extensive. Damages on the north and south Erie shores are estimated to have been $6,232,000 and $104,142,000, respectively, during the 1972-1975 high water period. Moreover, evidence suggests that shore property damages are increasing through time.

Third, the full economic costs of encroachments have not rested entirely with coastal hazard zone occupants. The Pelee and Rondeau case studies, in particular, show that the wider taxpaying public is increasingly bearing a higher portion of the costs of hazard land encroachment through increasing government shore protection subsidies. This is particularly important where the income redistributional

effects of such subsidies accrue to second home owners or higher income shore property owners.

Fourth, there are important environmental costs of shoreline encroachment which have also been neglected or given a low priority. Included are disruption of littoral processes, reduction of wetland areas and contamination of lake water by septic systems.

And fifth, in responding to Erie shoreline hazards, man has emphasized shore protection works. Often, these structures have increased the erosion hazard on adjacent properties, again reflecting an ignorance or neglect of coastal processes. Most structural adjustments in the study areas have been undertaken during or immediately after severe storms or high water periods and can be characterized as crisis response.

Governments at all levels have contributed to these problems by generally failing in the past to: adequately regulate coastal encroachments, particularly cottaging; adequately regulate construction of shore protection works; and absorbing an increasing share of the economic costs of encroachments.

It is instructive, therefore, to examine the nature and evolution of government policy for dealing with shoreline flood and erosion problems on Lake Erie.

NOTES

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CHAPTER IV

LAKE ERIE FLOOD AND EROSION HAZARD POLICY

This Chapter considers the nature of flood and erosion hazard policy as it relates to the Erie shoreline. An attempt is made to identify hazard policy goals or objectives and means of achieving these goals or objectives. Emphasis is on the present framework of federal, provincial, state and municipal government policies and the expression of these policies during the recent 1972-1975 high water period. Some attention is also given the historical evolution of the present framework of policies. In this respect, it is instructive to consider, first, certain basic models of policy-making and how these relate to the Lake Erie hazards problem. No attempt is made to outline in detail the politics of Erie shoreline hazard policy. For example, relationships among policy-makers including the struggle for budgets and influence and the role of the judiciary in modifying policy are important aspects affecting policy formulation not considered.

The Nature and Theory of Policy Formulation

Several models describing the policy-making process have been developed by researchers in political science and public administration. Among these are the rationalist, incrementalist and mixed scanning models of policy formulation.

The rationalist model of policy-making suggests that policies are formulated through a series of steps in which decision-makers recognize a policy problem exists, investigate the nature of the problem present alternatives, rank priorities, predict the risks and consequences of the various alternatives and come to a decision by combining the qualitative and quantitative values they have considered.(1)

The rationalist model, although somewhat optimistic in its suggestion that decision-makers are able to formulate policy in a systematic, structured and rational manner, does conform to some recent attempts by government to use such techniques as systems analysis, technological forecasting, benefit-cost analysis and program-planning-budgeting systems.(2) The systems approach, which underlies many of the other techniques, stresses interrelatedness and the necessity of considering the whole system and all factors bearing on it.

The real world of policy-making, however, seldom fits neatly into a systems framework. Systems analysis and

program-planning-budgeting were not designed to deal with such issues as value judgments, unquantifiable elements and the frequent need to compromise and adopt the second best solution.(3)

In reaction to the apparent shortcomings of the rationalist model, Lindlbom suggests that government policy-making is crisis management, where problems are dealt with as they arise with little attempt to anticipate them.(4) Government decision-makers "muddle through" a limited number of closely related alternatives in arriving at their decisions, without evaluating the consequences fully. The model stresses that large disruptive change is not likely to occur, as there is a sequential link with previous policies. Policy moves away from social ills, rather than toward some goal or objective.

Lindblom(1963) admits that the incrementalist approach neglects some possibly desirable non-incremental alternatives to policy problems. He suggests, however, that these alternatives are usually politically irrelevant.(5) Moreover, decision-makers often lack information or theory for dealing with large changes in policy.

A third approach to policy-making is the mixed scanning model developed initially by Etzioni(1967).(6) This model attempts to integrate features of both the rationalist and incrementalist approaches. It recognizes that both fundamental(rational) and incremental policy decisions are made and that the two types of decisions are very much

interrelated. Etzioni hypothesizes that most incremental decisions articulate or anticipate fundamental decisions, and that the cumulative effect of incremental decisions is greatly affected by the underlying fundamental decisions.

The incrementalist model is appealing because it seems to describe aptly the ad hoc nature of government policy-making, particularly with respect to natural hazards, and the failure of government to provide long term solutions to problems. The ad hoc, stop-gap, crisis management nature of natural hazard decision-making has been documented.(7) For example, in the United States during the 1803-1947 period, some 128 special, individual, after-the-fact disaster relief acts were passed before a general disaster relief act was introduced.(8) On the north Erie shore, ad hoc mainly structural responses to the flood and erosion problem have followed major high water periods.(9) The recent 1972-1975 crisis on Lake Erie precipitated considerable activity in the Ontario Legislature, as reflected in the Debates of the Legislative Assembly and in the introduction of several new programs for dealing with the flood and erosion hazard problem.

A major reason for the apparent failure of government to effect long term solutions to many 'crisis' problems may be the lack of sustained public attention on the problem and sustained public pressure for effective solutions. It has been suggested that many issues go through a cycle whereby a problem or crisis suddenly leaps into prominence, remains in

public view a short time and then, still largely unresolved, fades from public view and the attention of policy-makers.(10)

Flood and erosion problems, with their strong relation to periodic fluctuating lake levels, may reflect the cyclical nature of this "issue-attention" model very well. For example, near record high levels of the Great Lakes in 1951-1952 generated many representations to the Ontario government by shoreline occupants. On March 28, 1952, the Legislature established a Select Committee to investigate the problems of high lake levels, flooding and erosion on the Great Lakes and suggest solutions.(11) The Select Committee completed its report within a year, but the Government did not introduce the report until March 3, 1954. The level of Lake Erie was over 18 inches lower than two years previous, and the crisis on the Great Lakes had largely dissipated. This undoubtedly contributed to the fact that most of the Select Committee's recommendations, including the need for land use restrictions in shoreline areas, were not acted on.(12)

The news media, in its role informing the public and helping to shape public opinion, may be of some significance. In this regard, it is interesting to note that the extent of coverage of shoreline hazards shows a strong relationship to fluctuating lake levels and the occurence of major storms.(13) The media, with its

senstivitiy to 'newsworthiness', may well reflect the public's fluctuating interest in coastal hazards.

While the incrementalist model of policy formulation is most attractive in its realism, there is some evidence to suggest that fundamental changes in policy respecting hazards are possible and, in fact, are taking place. In the United States, the 1966 Task Force on Federal Flood Control Policy report represents a comprehensive and fundamental review of federal flood hazard policy.(14) Several of the Task Force's recommendations have been acted on, including the recommendation for a national flood insurance program. Indeed, the flood insurance program itself may represent a fundamental change in federal policy, particularly in its use of subsidized insurance to effect land use regulation in flood plains. Similarly, in Canada, there appears to be a significant shift in emphasis by the federal government from largely a structural approach to flood hazard to a more comprehensive approach that recognizes the importance of discouraging further encroachment into hazardous areas.(15) The federal government proposes to use its disaster relief program as a lever to encourage municipal government regulation of flood plains.

Therefore, a model of policy formulation, such as the mixed scanning approach, which realistically recognizes that many decisions must be incremental in nature, and at the same time views more fundamental changes in policy as possible and desirable, seems more appropriate as a

description of the process by which decisions are made respecting natural hazards in general. Certainly, such a model encourages a more rational approach to the hazards problem. However, it must be recognized that, while a more rational approach is desirable, most evidence available points to an incremental evolution of hazard policy as it relates to the Lake Erie shoreline.

Lake Erie Flood and Erosion Hazard Policy Goals and Means

Governments, at all levels, pursue three broad policies with respect to natural hazards. Governments seek to reduce hazard losses through a variety of structural and nonstructural means. Governments also seek to redistribute hazard losses, to lessen the burden of loss on individuals through various financial arrangements. As well, governments sometimes elect to follow a policy of doing nothing, letting individuals confront the hazard problem on their own terms. It should be noted that governments can and do pursue all three general policies contemporaneously, although for any particular crisis, one or more policies may be stressed.

Several goals or objectives appear to underlie these broad policies. The stated United States federal objectives in water resources management are national economic efficiency, regional development, environmental quality and social well being.(16) Similar goals or objectives for

water resource management in Canada have not been as explicitly stated. The Canada Water Act of 1970, the principal federal legislation in this field, provides a vehicle for federal and federal-provincial action relating to the conservation, development and utilization of water resources "to ensure their optimum use for the benefit of all Canadians".(17) While objectives for water resource management in Canada have not been explicitly outlined, objectives of national economic efficiency, regional development, environmental quality and social well being are implicit in some federal policies. For example, the Canada Water Conservation Assistance Act of 1953 required benefit-cost analysis for flood control projects designed by the provinces, suggesting that the federal government was concerned about economic efficiency. Similarly, the present federal environmental assessment and review process and Ontario environmental assessment legislation indicate a concern for environmental quality.

The many possible adjustments to flood and erosion hazards on the Lake Erie shoreline are outlined in Table 8. This theoretical range of adjustments is organized in terms of a model developed by Burton, Kates and White(1868) and subsequently modified by other natural hazard researchers.(19) In pursuing a policy of reducing hazard losses, governments can modify the hazard cause, modify the hazard, or modify the loss potential. Examples of each of these include diversions, seawalls and land use regulation.

TABLE 8

THEORETICAL RANGE OF GOVERNMENT HAZARD POLICY FOR THE LAKE ERIE SHORELINE

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Do Nothing
weather modification	seawalls	flood forecasting and warning	disaster relief	bear the losses on public property and let private property owners reduce or bear the losses
channelize the lake	groynes	emergency measures	subsidized insurance	
lake level regulation	gabions	flood proofing	tax write-offs	
diversions	dykes	zoning and land use regulation		
regulation of shore protection works and sand extraction	drains and pumps	sanitary regulation		
	breakwaters	subdivision regulation		
	beach nourishment	building codes and design		
	land filling	relocation		
	vegetation planting	temporary and permanent evacuation		
	encourage private property owners to undertake the above	land acquisition		
		encourage private property owners to undertake some of the above		

In pursuing a policy of redistributing hazard losses, governments can initiate measures such as tax write-offs and public relief. In pursuing a policy of doing nothing, governments, in effect, bear the losses on public property and let individuals bear the losses on private property, plan for the losses or undertake measures to reduce hazard losses.

The policy of doing nothing has been recognized as a legitimate response(19), and in many coastal areas letting individuals bear the losses may be a minimum cost solution best satisfying a goal of national economic efficiency. However, the option of doing nothing is not always open to governments. During times of crisis, governments at all levels are under great pressure to respond with measures aimed at reducing hazard losses or redistributing losses among taxpayers generally. Senior governments in particular are under pressure not only from individuals and special interest groups, but also from local governments and, in the case of federal governments, from state or provincial governments as well.

In a crisis atmosphere, costly, but simple and visible, structural solutions have been favoured to the neglect of more complex alternatives such as hazard land use zoning. Shore protection becomes a popular response to flood and erosion hazards.

Flood and Erosion Hazard Policy on the North Erie Shore

Federal Policy

Federal administrative structure and policy for dealing with flood and erosion hazard on the North Erie shore is summarized on Table 9.

Under the British North America Act, the regulation of natural resources is basically a provincial responsibility. This has discouraged the federal government from taking a strong and aggressive interest in flood and erosion problems.(20)

The federal government can regulate water resources through powers over navigation and shipping and sea coast and inland fisheries, even if the waters in question are located entirely within a single province.(21) However, these powers do not preclude provincial governments from regulating water resources with regard to provincial or local aspects.

Traditionally, it has been the policy of the federal government to consider flooding and erosion primarily the responsibility of local and provincial authorities.(22) In isolated cases where the magnitude of flooding was considerably beyond the ability of local interests to cope, the federal government has provided assistance. For example, the federal government undertook a substantial portion of the costs of a floodway around Winnipeg after the

TABLE 9

CANADIAN FEDERAL INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Fisheries and Environment (review shore construction permits)	Fisheries and Environment (cost sharing for protection works)	Fisheries and Environment (flood forecasting and warnings; land acquisition; public education; hazard mapping)	Finance (disaster relief)	Fisheries and Environment (hazard research
Transport (permits for shore construction)	Regional Economic Expansion (cost sharing for protection works)	National Emergency Planning Establishment (cost sharing for emergency measures)	National Revenue-Taxation (business tax write-offs)	International Joint Commission (studies of lake level regulation)
	Public Works (construction of protection works; cost sharing for protection works)	National Defense (flood fighting)		
	Indian and Northern Affairs (construction of protection works)	Central Mortgage and Housing Corporation (approves mortgage loans)		

devastating 1950 Red River flood.(23) The federal government has also been involved in protecting shorelines from erosion caused by federal structures or commercial navigation and a considerable amount of shore protection has been built by the Department of Public Works along the St. Lawrence, St. Clair and Detroit Rivers.(24)

On Lake Erie, the federal government has, on several occasions during major crises, provided ad hoc assistance for flood and erosion protection. In 1930, the Department of Public Works expended funds on shore protection in Harwich Township as an unemployment relief measure.(25) The federal government also provided assistance for shore protection in Harwich and Mersea Townships in 1951 and 1952, presumably for the protection of agricultural land.

The federal government formalized, to some extent, arrangements for assisting provinces with flood control works with the passage of the Canada Water Conservation Assistance Act in 1953. This Act authorized the Minister of Resources and Development(subsequently Energy, Mines and Resources) to enter into agreements with the provinces for major works for the conservation and control of water resources, with the federal government providing up to 37-1/2% of the costs of the project. This Act was repealed in 1970 with the passage of the Canada Water Act. No projects financed under the Canada Water Conservation Assistance Act involved Lake Erie.

The Canada Water Act authorizes the Minister of Fisheries and Environment to enter into federal-provincial agreements for water resource matters, including the development and implementation of comprehensive water management plans. Under this Act, a 1974 agreement between Environment Canada, Agriculture Canada and the Ontario Ministry of Natural Resources provided 90% senior government funding for the construction of shore protection works along Lake St. Clair.(26) Some funds from this agreement were used to complete a previous agreement between the Canada Department of Regional Economic Expansion and the Ontario Ministry of Agriculture and Food for shore protection in Harwich, Mersea and Pelee Townships on Lake Erie. This previous agreement, signed in 1973 under the federal Agricultural and Rural Development Act, also provided 90% senior government cost sharing.

In addition to cost sharing for shore protection works, Environment Canada is currently involved in a number of other activities relating to Lake Erie flood and erosion hazards. These include responsibility for forecasting Great Lakes water levels, issuing storm and flood warnings for shoreline areas, research on coastal processes, acquisition of land for wildlife purposes and responsibility for reviewing the environmental aspects of Ministry of Transport shore contruction permits. As well, Environment Canada was involved in the recent Canada-Ontario Great Lakes Shore

Damage Survey, a comprehensive study of erosion and flooding along the lower Great Lakes.

The federal government has operated water level gauges on Lake Erie since 1860, with the establishment of a gauge at Port Colborne.(27) More recently established gauges are located at Port Stanley, Port Dover, Erieau, Kingsville, Point Pelee and Bar Point. This system of gauges is now operated by the Canadian Hydrographic Service of Environment Canada, operating primarily out of the Canada Centre for Inland Waters in Burlington. On the basis of water level and weather information, the Canadian Hydrographic Service provides six month forecasts of probable lake levels. The Atmospheric Environment Service of Environment Canada has, since 1973 with the establishment of a Lake Level Advisory and Warning Service in their Toronto office, monitored Lake Erie water level gauges and weather conditions to provide short term storm surge and seiche forecasts for Lake Erie. A six to twelve hour advance warning of possible high levels is issued to appropriate officials.(28)

The Canada Centre for Inland Waters has been very active in research on coastal processes in the Great Lakes in recent years. Research has been undertaken in Lake Erie on beach erosion, storm surges, nearshore sedimentation and the effects of vegetation on bluff stability.(29) In 1973, Environment Canada, through its Centre for Inland Waters, undertook a cooperative survey of Great Lakes shore damage with the Ontario Ministry of Natural Resources. This survey

examined property damages, rates of erosion, shoreland ownership, use and value, and shoreline physiography.(30) A coastal zone atlas of the lower Great Lakes has been produced from data obtained during this survey. This survey is viewed as an initial step toward identifying shoreline management and planning alternatives.(31)

The Canadian Wildlife Service of Environment Canada has, over the past several years, acquired 1,857 acres of marsh along Lake Erie, mainly in the Long Point area.(32) These purchases of highly hazardous shore areas, although primarily for wildlife purposes, serve to reduce the amount of private land along Lake Erie which might eventually come under development pressure.

Environment Canada, under its Environmental Assessment and Review Process, initiated in 1973, is responsible for reviewing applications for shore construction under the federal Ministry of Transport permit program for possible adverse environmental effects.(33) If effects are thought to be significant, recommendations are made to prevent or minimize major environmental impacts. Under the Environmental Assessment and Review Process, Environment Canada now has responsibility for environmentally screening major federal and federally-related works. With respect to shore protection works, this responsibility was met only in the case of the Port Burwell breakwall.(34)

Since the passage of the Agricultural and Rural Development Act in 1961, the federal Departments of

Agriculture and Regional Economic Expansion have provided matching financial assistance with the Ontario Ministry of Agriculture and Food for agricultural land drainage and shore protection for farmland along Lake Erie. Following the severe November 1972 storm and flooding in western Lake Erie, an agreement was signed in May of 1973, by the federal Minister of Regional Economic Expansion and the provincial Minister of Agriculture and Food, to provide 90% of the costs of shore protection for municipal drainage schemes in Harwich, Mersea and Pelee Townships.(35)

While the federal Department of Public Works has mitigated, for many years, the erosional effects of commercial navigation and federal works along the St. Clair and Detroit Rivers, a policy was formalized in 1966.(36) Under this policy, the federal government has provided grants to assist in the construction of approved shore protection works for several municipalities and for a number of property owners on the Erie shoreline where erosion has been exacerbated by federal navigation structues.(37) The amount of federal assistance depends on the degree to which erosion can be attributed to the federal structure.

The only other federal agency involved in the construction of shore protection works is the Department of Indian and Northern Affairs, under its management of Point Pelee National Park. The Department has experimented, over a number of years, with various structural methods in an attempt to reduce erosion.(38)

The National Emergency Planning Establishment provides grants to local emergency measures organizations and is involved in the administration of federal disaster aid. Under the federal disaster relief scheme, a province must pay the first dollar per capita of provincial population. The federal government contributes 50% of the next $2.00 per capita, 75% of the next $2.00 per capita and 90% of all damage costs over $5.00 per capita.(39) The Canada Department of Finance cooperates with the National Emergency Planning Establishment on the administration of this program. Eligible costs under the program do not include seasonal residences, but do include the costs of temporary dykes, temporary accommodation, restoring public works such as roads, reimbursing private individuals for property losses, and restoring permanent homes, farm buildings and small businesses to pre-disaster condition.(40) Because of the large size of the Ontario population relative to the damages involved, this program has not been used on the north Erie shore or elsewhere on the Great Lakes.

The Department of National Defense has provided Canadian Armed Forces personnel and equipment during some natural disasters in Canada, for example, the 1973 New Brunswick flood.(41) The Ontario government did not call upon the flood fighting assistance of the Armed Forces during the recent Lake Erie high water period.

Central Mortgage and Housing Corporation, in cooperation with lending institutions, makes mortgage loans

available to Canadians under the National Housing Act. Central Mortgage and Housing Corporation could exercise some influence on home construction in hazardous areas, as their officials undertake inspections of subdivisions and individual lots prior to approval of mortgage applications by home builders.(42) There do not appear to be any formalized guidelines regarding natural hazards, rather, Central Mortgage and Housing Corporation officials from local office apparently are familiar with local conditions and judgments are made on this basis.

The Ministry of Transport administers the Protection of Navigable Waters Act, which regulates construction in navigable waters. In theory, most shore protection works along the Erie shoreline should require either a permit or exemption from permit from the Ministry. In practice, an arrangement has been made with the Ontario Ministry of Natural Resources, which regulates construction on public land under Lake Erie.(43) The Ministry of Natural Resources refers only larger works to the federal Ministry of Transport for approval. The Ministry of Transport issued 65 permits or exemptions from permit on Lake Erie during the 1972-1975 high water period(44).

In Canada, there is no provision whereby property owners can deduct from taxable income any losses incurred as a result of flood and erosion hazards. However, the Canada Department of National Revenue-Taxation allows commercial operators to claim as business expenses such costs as flood

and erosion damages and shore protection works, to effect a reduced taxable income.(45)

At the international level, the federal government cooperates with the United States on water resource and other problems through the International Joint Commission established by the Boundary Waters Treaty of 1909. The Commission has quasi-judicial, investigative, surveillance, and coordinating functions. The Commission established the International Great Lakes Levels Board in 1964 to investigate the question of fluctuating water levels on the Great Lakes. The Commission became further involved in lake levels in 1973, when it instructed the International Lake Superior Board of Control to decrease outflows from Lake Superior as an emergency measure to help reduce levels on the lower lakes.(46)

Federal government hazard policy on the north Erie shore has stressed structural measures that attempt to modify the hazard. In a more general Canadian context, federal involvement in natural hazards has been directed toward structural measures, disaster relief and, to a lesser extent, emergency measures. Recently, however, the Canada Department of Environment has articulated a new strategy for flood damage reduction in Canada.(47) This strategy is based on a program of flood risk mapping and suggests that federal agencies will not develop or support development in identified flood risk areas. As well, federal disaster assistance will be refused with respect to any further

development in these identified areas. Provinces will be asked to restrict their investments in identified flood risk areas and encourage zoning regulations by local governments. This new federal strategy seems to reflect a shift towards nonstructural solutions to flooding. Apparently, this new strategy will apply initially to riverine flood problems in urban centres, rather than shoreline areas.

A very recent draft policy statement on federal involvement in shoreline erosion also reflects a greater emphasis on nonstructural hazard adjustments.(48) This statement makes no commitment to assistance for erosion problems beyond the present Canada Department of Public Works policy on erosion due to federal navigation structures or commercial shipping. Rather, the draft policy supports federal involvement in erosion research and identification and mapping of erosion risk areas.

Provincial Policy

Although a number of federal agencies are currently involved in the Lake Erie flood and erosion hazard problem, the principal responsibility for these hazards has rested traditionally with provincial and municipal authorities.

Ontario provincial administrative structural and policy for dealing with flood and erosion hazards on the north Erie shore is summarized on Table 10.

TABLE 10

ONTARIO PROVINCIAL INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Natural Resources (permits for shore construction and sand extraction)	Natural Resources (construction of protection works; cost sharing for protection works; technical advice on protection works) Agriculture and Food (cost sharing for protection works) Treasury (cost sharing and loans for protection works) Transportation and Communications (construction of protection works)	Natural Resources (land acquisition; hazard mapping) Transportation and Communications (flood fighting) Emergency Measures Branch (cost sharing for emergency measures) Environment (septic system approval) Housing (official plans; subdivision control)	Treasury (disaster relief) Revenue (property tax write-offs)	Inter-Ministry Flood Damage Working Group (coordinates provincial hazard programs)

The Ministry of Natural Resources, for example, is involved in Erie shoreline hazards in a number of ways. Acting through its Conservation Authorities Branch and local conservation authorities, the Ministry can share the costs of flood and erosion protection works with municipalities. The Ministry manages many miles of Erie shoreline within provincial parks such as Rondeau, Long Point, Holiday Beach and Wheatley, and is currently examining the erosion problem at Rondeau.(49) The Ministry can acquire land for park, wildlife and other purposes.

The Ministry of Natural Resources, as provincial agency responsible for the Public Lands Act, issues permits for shore protection on public land and commercial extraction of sand and gravel from beaches and the Lake bed.(50) For construction of shore protection works, an applicant must generally supply approvals from adjoining property owners. A site inspection is undertaken by the Ministry, but there do not appear to any specific guidelines respecting environmental considerations. The Chatham District of the Ministry of Natural Resources discourages, however, groynes longer than 100 feet. Some 200 permits were issued along the Erie shoreline in Essex and Kent Counties during the 1972-1975 high water period.(51) Apparently, other Districts of the Ministry do not enforce the permit program elsewhere along Lake Erie.(52) There is a feeling that shore protection is largely on private land and does not, therefore, require a permit.

The Beach Protection Act authorizes the Minister of Natural Resources to regulate the extraction of sand, gravel and stone from the bed, bank, beach, shore or water of any lake, river or stream. The Minister can refuse to grant a license for commercial extraction, or cancel an existing one, if the extraction interfers with the natural state or use of waters, value or use of property, or causes undue erosion or accretion. Regulations under this Act protect approximately 6,500 feet of beach along Lake Erie in Harwich, Colchester South and Malden Townships from any extraction, commercial or otherwise.(53)

The Ministry of Natural Resources offers assistance to private property owners along the Lake Erie shoreline in several respects. In cooperation with the Ministry of Transportation and Communications, the Ministry has made sandbags available to property owners for flood fighting purposes during the recent high water period. During this period, the Ministry also offered an extension service program to provide technical assistance to property owners and municipalities on shore protection. Over 100 assignments were conducted on the Erie shoreline in Essex and Kent Counties at an estimated cost of $15,000.(54) This program encouraged technically sound shore protection, rather than the usually ineffective protection erected by property owners. However, advice was limited to shore protection, as opposed to flood proofing or relocation of structures.

The Ministry of Natural Resources exercises some influence on land use planning matters. Hazard land policies developed by the Ministry have recently been incorporated in municipal official plans. For example, the Official Plan for the Central Elgin Planning Area includes a policy statement on development along the Lake Erie shoreline. Structures are allowed within a designated shoreline area only if erosion at the proposed building site has been eliminated by a stabilization program approved by the local conservation authority and municipal council and designed and supervised by a registered professional engineer.(55) As well, the Ministry of Natural Resources provides financial and technical assistance to local conservation authorities, which can regulate development on hazard land.

The Ministry of Agriculture and Food currently administers land drainage matters in Ontario. Various arrangements, such as the Municipal Drainage Aid Act of 1872 and the Provincial Aid to Drainage Act of 1900, as amended, have aided the development of large scale drainage schemes in the Rondeau and Pelee areas, and subsequent protection of these schemes from flooding and erosion.(56) Over the years, the amount of provincial subsidy for these schemes has increased, from 20% during the 1921-1954 period to 33-1/3% after 1954, with an additional 33-1/3% federal A.R.D.A. grant after 1961. For the recent dyking in Pelee,

and Harwich Townships, the provinical and federal governments each contributed 45% of total costs.

The Ministry of Treasury, Economics, and Intergovernmental Affairs administers several programs affecting Lake Erie flood and erosion hazards. First is the Post Disaster Assistance program which has been in operation since before 1950. It provides matching provincial dollar contributions for every dollar raised locally in Cabinet-declared disaster areas. This program, which was used in Essex and Kent Counties following the November 1972 flood, provided approximately $165,000 in provincial assistance to permanent residents and farmers.(57) Cottagers are not eligible for disaster relief under this program. As well, relocation of buildings damaged by a disaster are not ordinarily eligible for assistance. However, where rebuilding on the original site is impossible or impractical due to the disaster, assistance with the cost of relocation of the building to predisaster condition, may be considered by the local disaster relief committee which collects local contributions and disburses relief funds.(58) Notwithstanding, the program does not encourage or facilitate relocation of structures.

The Ministry of Treasury, Economics and Intergovernment Affairs also administers the Shoreline Property Assistance program and the Special Emergency Assistance program, both initiated following the November 1972 flood. The Shoreline Property Assistance Act of 1973 authorizes the Minister to

loan funds to municipalities for the purpose of extending loans to propertly owners, including cottagers, for repair of flood or erosion damaged buildings and construction of shore protection works. The Special Emergency Assistance program is designed to assist municipalities with the protection of roads and other public property.(59)

As well as cooperating in the distribution of sandbags to shore property owners, the Ministry of Transportation and Communications, during the 1972-1975 high water period, undertook protection of provincial highways in the Haldimand-Norfolk Region and Essex County at a cost in excess of $189,000.(60)

The Emergency Measures Branch of the Ministry of the Solicitor-General, has provided support to local emergency measures organizations along the north Erie shore. However, the Province dissolved this Branch at the end of 1975.(61)

The Ministry of Housing is currently responsible for the Planning Act, the major land use planning legislation in Ontario. This Act deals with municipal official plans, zoning bylaws, land division committees and subdivision control throughout the Province. While considerable land use planning power is delegated to municipalities, the Ministry of Housing approves official plans, plans of subdivision and zoning bylaws. In 1973, the Province issued Minister's zoning orders for townships along the Erie shoreline in Haldimand and Norfolk Counties.(62) This measure to regulate lakeshore development was primarily a

response to the Nanticoke industrial development and impending local government reorganization. These Minister's orders, which override local zoning bylaws, will likely remain until the Regional Municipality of Haldimand-Norfolk, established in 1974, has an approved official plan to guide development.

The Ministry of the Environment also exerts some control on land use planning, through approval power over water supply and sewage disposal systems, including septic tank installations. Although the Ministry, under the Environmental Assessment Act, now environmentally assesses and approves major provincial and ultimately municipal and private undertakings, this legislation was not in force until after the 1972-1975 high water period.

The Ministry of Revenue, through the Assessment Act, provides for reduced tax assessment on properties depreciated due to flooding or erosion.(63)

Flood and erosion hazard programs of the provincial government have been coordinated during the recent high water period by the Inter-Ministry Flood Damage Working Group, established in 1973.(64) This temporary Working Group consists of representatives of the Ministries of Natural Resources, Agriculture and Food, Solicitor-General, Transportation and Communications, Environment and Treasury, Economics and Intergovernmental Affairs. The Working Group was empowered to allocate funds and Ministry resources, as well as disseminate information to the public and

municipalities regarding various provincial shoreline hazard programs.

The Province is responsible for a wide range of programs affecting Lake Erie flood and erosion hazards. As with the federal government, however, emphasis has been on structures that aim to modify the hazard. It remains to seen what impact the recent provincial practice of incorporating hazard policies in municipal official plans will have.

Municipal Policy

Typically, municipalities appeal to senior levels of government for assistance during periods of high lake levels and immediately following disastrous storms. Within one month of the November 1972 storm on Lake Erie, several north Erie shore municipalities had sent petitions and delegations to the provincial government requesting assistance.(65) Municipalities also enlisted the support of local members of the provincial legislature and federal House of Commons in pressing senior governments for assistance.

There are 31 municipal governments on the north Erie shoreline. These municipalities can and do undertake some action with respect to shoreline hazards. A number of municipalities on the Erie shoreline made emergency road and dyke repairs during and after the 1972-1975 storms. Mersea, Pelee and Harwich Townships administered federal-provincial

dyking assistance under the Drainage Act. These municipalities retained engineers to investigate the problem and let contracts for the construction of protection works. As well, a number of municipalities administered loans to property owners under the Shoreline Property Assistance program and applied for assistance under the Special Emergency Assistance program.

A number of municipalities in Essex and Kent counties formed the Essex-Kent Disaster Relief Committee to solicit local contributions and administer matching provincial relief funds.

Several local emergency measures organizations along the north Erie shore were active during the recent high water period, providing flood warnings and coordinating local emergency measures.(66)

Recently, extensive shoreline areas along Lake Erie have been incorporated into existing conservation authorities or, in the case of Essex County shoreline, into a newly created authority.(67) High lake levels and flood and erosion problems were motivating factors in the expansion of authorities into lakeshore areas. Under the Conservation Authorities Act, local authorities can acquire land and make regulations regarding flood plain zoning and land filling. The Essex Region Conservation Authority has recently undertaken an extensive survey of the lakeshore to identify hazardous areas and recommend practical corrective measures and land use policies.(68)

Very recently, at least one local conservation authority has begun to exercise some influence in municipal land use planning. The Kettle Creek Conservation Authority objected to approval of several severances along the Erie shoreline by the Elgin County land division committee. The Authority forced a hearing before the Ontario Municipal Board, which rejected the severance approvals on the grounds they contravened the hazard policies of the official plan.(69) As well, recent action by the Regional Municipality of Haldimand-Norfolk suggests an increasing interest in municipal regulation of land use. Pending approval of a regional official plan, regional council introduced a coastal land use policy in 1976 as a basis for approving or denying development applications.(70)

However, up to and including the 1972-1975 high water period, municipalities and local agencies such as the conservation authorities had not been aggressive in controlling development in hazardous north Erie shoreline areas.

Flood and Erosion Hazard Policy on the South Erie Shore

Federal Policy

Federal administrative structure and policy for dealing with flood and erosion problems on the South Erie shore are summarized on Table 11.

TABLE 11

UNITED STATES FEDERAL INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Corps of Engineers (permits for shore construction)	Corps of Engineers (construction of protection works; cost sharing for protection works)	Corps of Engineers (hazard mapping; public education)	Housing and Urban Development (disaster relief; flood insurance; temporary housing)	Corps of Engineers (hazard research; damage surveys)
Environmental Protection Agency (reviews environmental impact statements)	Agriculture (cost sharing for drainage)	Housing and Urban Development (promotes emergency measures planning)	Agriculture (disaster relief)	Water Resources Council (planning and coordination)
	Interior (construction of protection works)	Commerce (flood forecasting and warning; cost sharing for coastal zone management)	Commerce (disaster relief)	Great Lakes Basin Commission (planning and coordination)
	Transportation (cost sharing for protection works)	Interior (hazard mapping; land acquisition)	Internal Revenue Service (income tax write-offs)	International Joint Commission (studies of lake level regulation)

For many decades, the federal government has been involved in flood and erosion problems throughout the United States. This involvement in flooding, erosion, and, more generally, water resources and civil works, stems from the General Survey Act of 1824, which authorized the Corps of Engineers to improve the nation's waterways. Constitutionally, this involvement has evolved from the federal power to regulate commerce, including navigation.(71)

In the early 1800's, specific federal interest in flood control began in the Mississippi River basin where the interrelated nature of navigation and flood control became apparent.(72) With the passage of the Flood Control Act of 1936, flood control in the United States became virtually a 100% responsibility of the federal government.(73) Flood control on navigable waters or their tributaries was deemed to be a matter of general welfare and therefore an appropriate activity of the federal government.(74) This Act, and subsequent amendments, provides for 100% federal financing of flood control works, with nonfederal interests providing all land, easements, operating and maintenance costs, as well as holding the federal government free of all damages. Subsequent legislation, such as the Flood Control Act of 1955, providing for Corps of Engineers emergency flood protection and measures, and the Flood Control Act of 1960, authorizing Corps of Engineers involvement in flood plain mapping, has broadened federal interest in flooding.

Prior to 1930, federal interest in shore erosion was restricted to the protection of federal property and navigation improvements.(75) The River and Harbor Act of 1930 established a Beach Erosion Board and authorized the Corps of Engineers to study local erosion problems at the request of states and local interests on a 50% cost sharing basis. The River and Harbor Act of 1946, as amended, provides for up to 70% federal cost sharing for the construction of erosion protection benefiting public property or interests. As with local flood protection projects, local interests must provide necessary land and easements, maintain and operate the projects, and hold the federal government free of any damages. Legislation in 1963 abolished the Beach Erosion Board, transferring its functions to the Board of Engineers for River and Harbors, and established the Coastal Engineering Research Center at Fort Belvoir, Virginia.(76)

Federal interest in shore erosion on the south Erie shore has been considerable. The Corps of Engineers has made a number of investigations of shore erosion, particularly in Ohio.(77) The Corps has undertaken several cooperative beach erosion control projects on public property, including the Presque Isle project. Under the River and Harbor Act of 1968, the Corps is authorized to investigate and mitigate erosion due to federal navigation works. Private property can be protected under this program, and the Corps is presently investigating federal

navigation works on Lake Erie at Bolles Harbor and Monroe, Michigan, and Vermilion, Cleveland, Fairport, Ashtabula and Conneaut, Ohio.(78) Under the Shoreline Erosion Control Demonstration Act of 1974, several erosion control projects are likely to be undertaken on the south Erie shore. Private property is eligible for protection under this limited program, but private interests must contribute 25% of the costs. Except for erosion induced by federal structures, demonstration projects and where public recreational or other benefits result, the federal government can not subsidize the protection of private property from erosion.

The Corps of Engineers shares the cost of flood protection on the Great lakes shoreline, including private property. Following the 1952 floods on Lake Erie, the Corps of Engineers did undertake a project for protection of private property against floods at Estral Beach, Michigan.(79) Federal cost for this dyking project was $181,200. As well, many miles of private shoreline along Lake Erie were protected by temporary dykes in 1973 and 1974 under the Corps of Engineer's Operation Foresight program.

In addition to its involvement in protection works for erosion and flooding, the Corps of Engineers is currently involved in a number of other activities affecting the south Erie shore. These include flood fighting, hazard mapping, flood and erosion hazard research, surveys of property damage following floods and issuing permits for

construction, dredging and land filling along the shoreline below the mean high lake level.

The Department of Housing and Urban Development is also very much involved in Lake Erie shoreline hazards. Its Federal Disaster Assistance Administration supports state government emergency planning for natural and other disasters and provides disaster relief for local and state public property under the Disaster Relief Act of 1974 and earlier legislation. Under this program, the Federal Disaster Assistance Administration granted approximately $2,000,000 to Michigan and $3,000,000 to Ohio as a result of Lake Erie flooding and erosion during 1972-1980 period.(80) The Federal Insurance Administration of the Department of Housing and Urban Development administers the National Flood Insurance Program, providing subsidized insurance for flooding and storm induced erosion.(81) To be eligible for this program, communities must enact hazard land regulations to discourage further hazard susceptible development. The Federal Insurance Administration contracts with private consultants and other federal agencies for hazard mapping under the flood insurance program. The Department of Housing and Urban Development also supplies temporary housing for disaster victims.

The Department of Agriculture provides financial assistance for land drainage to farmers organized in conservation districts or similar public or quasi-public groups.(82) As well, the Farmers Home Administration of the

Department of Agriculture provides natural disaster loans and grants to farmers. During the 1972-1975 high water period, over $2,000,000 in loans were distributed to farmers along the Lake Erie shoreline in Michigan and Ohio.(83) Approximately $1,500,000 of this total was forgiven, representing a public subsidy.

The Department of Commerce is involved in several important aspects of flood and erosion hazard policy affecting the Erie shoreline. The Small Business Administration of the Department of Commerce provides disaster relief loans and grants to homeowners and small businessmen.(84) The National Oceanic and Atmospheric Administration monitors and predicts lake levels and forecasts storms and flooding and issues warnings.(85) In this regard, the National Weather Service office in Cleveland is an important centre of activity for storm forecasts on Lake Erie. Lake levels have been monitored by the Lake Survey Center of the National Oceanic and Atmospheric Administration, and previously by the Corps of Engineers, since 1838 at the gauge at Cleveland. A number of other gauges have subsequently established along the Erie shoreline.

The National Oceanic and Atmospheric Administration is also responsible for the Coastal Zone Management Act of 1972, which provides for federal grants of up to 80% of the cost of developing and implementing approved state coastal zone management plans. These plans will delineate flood and

erosion hazard areas and develop appropriate land use guidelines. Coastal zone programs are being developed in the four states bordering Lake Erie.

The Department of Interior is responsible for national parks and wildlife areas, such as the Ottawa National Wildlife Area in Ohio where shore protection works have been constructed to maintain water levels in the marsh. The Department of Interior can acquire land for wildlife and recreational purposes. The Geological Survey of the Department undertakes hazard mapping for the National Flood Insurance program.

The Department of Transportation provides cost sharing for the protection and repair of federal-aid highways affected by flooding and erosion.

The Internal Revenue Service of the U.S. Department of Treasury allows hazard damages as eligible deductions from both business and personal taxable income.(86) Taxpayers can deduct that portion of "sudden, unexpected, and unusual" damages to property from disasters such as flooding and storm induced erosion that is not reimbursed by insurance or public disaster relief. Damage from gradual shore erosion would not be an eligible deduction.

It has been estimated that between 15% and 25% of the unsubsidized portion of private disaster losses is absorbed by the Internal Revenue Service and, hence, United States taxpayers generally.(87) Applying a median estimate of 20% suggests that federal government tax write-offs for the Erie

shoreline residents and businessmen amount to $10,661,000 as a result of the November 1972 and March-April 1973 storms in Michigan and Ohio.

The federal Water Resources Council, established by the Water Resources Planning Act of 1965, coordinates and reviews water and related land resource planning, establishes and assists river basin commissions and establishes principles for the evaluation of federal water and related land projects. The Great Lakes Basin Commission was established in 1967 under the auspicies of the Water Resources Council and is composed of the eight Great Lakes states and a number of federal agencies. The Commission recently completed a detailed study of Great Lakes basin problems, including shoreline flooding and erosion.(88)

The Council on Environmental Quality and Environmental Protection Agency, established by the National Environmental Policy Act of 1969, review all draft and final environment impact statements associated with projects and permit applications of the Corps of Engineers and other federal agencies to ensure compliance with the intent of the environmental assssment procedures embodied in the National Environmental Policy Act.

The United States government also participates with Canada in the International Joint Commission, specifically the International Great Lakes Levels Board as described previously..

Federal government policy on the South Erie shore has stressed both structural measures that aim to modify the hazard and various disaster relief programs that simply redistribute losses among United States taxpayers generally. The policies of federal agencies are firmly entrenched in legislation that has evolved over the years, often in response to particular storms or other disasters. Recent legislation, such as National Environmental Policy Act, National Flood Insurance Act and Coastal Zone Management Act, reflects a growing concern for the environmental effects of engineering works and desirability of considering nonstructural solutions to such problems as flooding and erosion.

State Policy

The policies of four states, Michigan, Ohio, Pennsylvania and New York, relate to flood and erosion hazards on the south Erie shoreline. State administrative structure and policy for dealing with flooding and erosion on the Lake Erie shoreline in Michigan are summarized on Table 12.

In Michigan, the Department of Natural Resources is involved in a number of aspects relating to shoreline flooding and erosion. The Department can construct works protecting parks and other state property. In times of crisis, the Department has assisted with flood fighting and

TABLE 12

MICHIGAN STATE INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Natural Resources (permits for shore protection, land filling and dredging)	Natural Resources (construction of protection works) State Highways (construction of protection works) Agriculture (technical advice on drainage	Natural Resources (flood fighting; hazard mapping; subdivision control; coastal zone management; land acquisition) State Policy (supports local emergency measures) Treasury (subdivision control) National Guard (flood fighting) Corrections (inmates for flood fighting)	Treasury (business tax write-offs; property tax write-offs)	Great Lakes Commission (promotes regional interests) Great Lakes Basin Commission (planning and coordination)

restorative measures, such as pumping of excess water. The Department of Natural Resources is responsible for administering the Shorelands Protection and Management Act of 1970, which provides for the identification of high risk erosion, flood risk and environmental areas along the Great Lakes shoreline in Michigan and the formulation of policies and appropriate land use controls and other regulations for these areas.(89) This Act provides for state enforcement of land use regulations for identified high risk erosion, flood risk and environmental areas, if local governments fail to adopt the necessary regulations.

The Michigan Department of Natural Resources reviews proposed subdivision plans for areas adjacent to water bodies and can prohibit or restrict residential construction within flood plains.(90) The Department also administers the Great Lakes Submerged Lands Act of 1955, which provides for the issuance of permits for shore protection, land filling, and dredging on land along the Great Lakes below the ordinary high water line.

The Michigan Department of State Highways and Transportation, which is responsible for repair and protection of state highways, has not experienced any significant problems with respect to recent high levels of Lake Erie, but potentially could be involved if damages occur.(91)

The Department of State Police plays a central role in Michigan in coordinating emergency measures and flood

fighting with respect to Lake Erie.(92) The Department provides coordination and assistance to local governments in planning for, and recovery from, disasters. Both the National Guard and the Department of Corrections, which has supplied volunteer inmates, assist with flood fighting operations.

The Michigan Department of Agriculture provides technical and adminstrative assistance with regard to agriculture drainage and flood protection of farmland, but does not provide financial assistance.(93)

The Department of Treasury exercises final approval of all subdivision plats in Michigan and assures that draft plans of subdivision have been circulated to appropriate agencies such as the Department of Natural Resources for comment.(94)

The Michigan Department of Treasury allows a deduction of flood and erosion damages from taxable business income only.(95) However, all property owners can appeal their property tax assessment for any loss due to flooding or erosion. Moreover, a recent law exempts, from property tax, shore protection works designed primarily to prevent flooding and erosion.(96) This provision is unique along the Lake Erie shoreline. Elsewhere, such protection would probably add to the value of property and, hence, assessment.

Michigan is a member of the Great Lakes Commission, an interstate compact established in 1955 to coordinate and

promote regional interests related to the Great Lakes.(97) The Commission presented briefs on Great Lakes water levels and flood and erosion hazards to the 1974 International Joint Commission hearings on lake levels as well as to the Congress water resources hearings in 1973. The Great Lakes Commission has been lobbying for further regulation of Great Lakes levels and for additional federal assistance for the protection of both public and private shoreline.(98) Michigan is also a member of the Great Lakes Basin Commission, which has been previously described.

State administrative structure and policy for dealing with flood and erosion hazards on the Lake Erie shoreline in Ohio are summarized on Table 13.

For many years, Ohio has been involved in Lake Erie erosion. A Division of Shore Erosion was established within the Department of Public Works in 1935.(99) This Division was subsequently transferred to the Department of Natural Resources in 1949. The Department of Natural Resources has conducted a number of investigations of shore erosion and flooding in Ohio.(100)

The Department of Natural Resources is responsible for the protection of state property from shoreline flooding and erosion. A number of projects aimed at arresting erosion along Ohio's Lake Erie shoreline have been constructed.(101) The Department can share the costs of shore protection on municipal and private land under legislation enacted in 1953, following the 1951-1952 high water period on Lake

TABLE 13

OHIO STATE INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Natural Resources (permits for shore protection and sand extraction)	Natural Resources (construction of protection works; cost sharing for protection works) Transportation (construction of protection works)	Natural Resources (land acquisition; coastal zone management) Adjutant General (supports local emergency measures)	Taxation (income tax write-offs) Board of Tax Appeals (property tax write-offs)	Natural Resources (erosion research) Great Lakes Commission (promotes regional interests) Great Lakes Basin Commission (planning and coordination)

Erie. Under this arrangement, the Department can contribute 66-2/3% of the costs of protection of municipal land and 33-1/3% of the costs for private property protection. In practice, however, funding limitations have prevented financing of works for other than state property.(102)

The Ohio Department of Natural Resources can acquire land for recreation and other purposes. Consideration has been given, recently, to the purchase of 60 acres in Reno Beach. Land in this vicinity was flooded three times within five months in 1972-1973 and many homeowners wanted an opportunity to sell their properties.(103) The Department provides assistance to municipalities in drafting land use controls for hazard lands and is responsible for a coastal zone management program which is only in the initial stages. This program was seriously jeopardized in 1975 by personnel cutbacks resulting from state austerity measures.(104)

The Department of Natural Resources issues permits for shore protection along Lake Erie and regulates offshore commercial sand and gravel extraction. Over 1,600 shore protection permits were issed during the 1972-1975 high water period.(105)

The Department of Transportation has protected and repaired roads affected by flooding and erosion on Lake Erie. For example, about $142,000 was spent protecting State Route 531 in Ashtabula County from erosion during the recent high water period.(106)

The Disaster Services Agency of the Adjutant General's department administers federal disaster relief to public agencies in Ohio, coordinates emergency measures and supports local emergency measures organizations.(107)

The Department of Taxation provides for both individual and business income tax write-offs due to flooding and storm-induced erosion.(108) These write-offs are estimated to be $311,000 as a result of storms during 1972 and 1973.(109) As well, all property owners can appeal to the state Board of Tax Appeals for reduced property tax assessments.(110)

Like Michigan, Ohio is a member of both the Great Lakes Commission and Great Lakes Basin Commission.

State administrative structure and policy for dealing with flooding and erosion on the Lake Erie shoreline in Pennsylvania are summarized on Table 14.

The Department of Environmental Resources has undertaken construction of shore protection on state land, notably at Presque Isle State Park. The Department has also cooperated with the U.S. Army Corps of Engineers in the construction of shore protection works and beach nourishment at Presque Isle.

The Department of Environmental Resources offers technical advice to property owners on shore hazard problems, and has permit authority over the construction of shore protection works, land filling, and dredging.(111) As well, the Department has instituted a coastal zone

TABLE 14

PENNSYLVANIA STATE INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Environmental Resources (permits for shore protection, land filling and dredging)	Environmental Resources (construction of protection works)	Environmental Resources (permits for septic systems; land acquisition; coastal zone management) Council of Civil Defense (supports local emergency measures; warning system) Community Development (technical advice on land use regulation	Revenue (business tax write-offs)	Great Lakes Commission (promotes regional interests) Great Lakes Basin Commission (planning and coordination)

management program and has mapped flood and erosion hazards along Lake Erie. Lakefront land use regulation is viewed as a possible end product of this coastal zone program.(112)

The State Council of Civil Defense administers federal disaster aid in the Commonwealth. The Council also coordinates local civil defense units and relays disaster warnings to these local units.(113)

In Pennsylvania, land use zoning and subdivision approval are strictly concerns of local government.(114) However, the Department of Environmental Resources does exercise some control over development through the regulation of septic systems.(115) The Department of Community Development offers technical assistance on land use regulations and coordinates the National Flood Insurance program within Pennsylvania.(116)

The Pennsylvania Department of Revenue provides for income tax write-offs for businesses only.(117) There does not appear to be any provision in Pennsylvania law for reduced property taxes as a result of natural disasters.(118)

As with Michigan and Ohio, the Commonwealth of Pennsylvania participates in both the Great Lakes Commission and Great Lakes Basin Commission.

State administrative structure and policy relating to flood and erosion hazards on the Erie shoreline in New York are summarized on Table 15.

TABLE 15

NEW YORK STATE INVOLVEMENT IN ERIE SHORELINE HAZARDS

Reduce Hazard Losses				
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute Hazard Losses	Other
Environmental Conservation (permits for shore protection, land filling and dredging)	Environmental Conservation (cost sharing for protection works) Transportation (construction of protection works)	Environmental Conservation (land acquisition; coastal zone management) Military and Naval Affairs (supports local emergency measures)	Taxation and Finance (income tax write-offs) Board of Equalization and Assessment (property tax write-offs)	Great Lakes Commission (promotes regional interests) Great Lakes Basin Commission (planning and coordination)

Under New York law, there is provision for state participation in shore protection on public lands, but financial assistance to date has been limited to New York's Atlantic coast.(119) The Department of Environmental Conservation, however, is involved in Erie shoreline hazards in several other ways. In 1975, the Department initiated a coastal zone management program that will include consideration of land use controls and structural protection measures.(120) The Department has permit authority over lands below the mean high water level for shore protection works, land filling and dredging.(121) As well, the Department exercises some control over drainage projects within drainage improvement districts.(122)

The Division of Military and Naval Affairs is responsible for administering federal disaster aid to state and local agencies and coordinating emergency measures efforts of local civil defense units.(123)

The New York Department of Transportation is responsible for maintaining and protecting state highways and recently has undertaken shore protection works at several points along Lake Erie in New York at a cost of $25,000.(124)

As in Ohio and Pennsylvania, the State of New York does not exercise any control over zoning and subdivision matters, which are local responsibilities.(125) Recent legislation in New York, however, permits the Department of Environmental Conservation to regulate flood plain uses in

communities which do not participate in the federal flood insurance program.(126)

The New York Department of Taxation and Finance permits personal and business income tax write-offs for losses due to flooding and storm induced erosion.(127) The State Board of Equalization and Assessment permits property tax write-offs due to flood and erosion damages.(128)

As with Michigan, Ohio and Pennsylvania, New York is a member of both the Great Lakes Commission and Great Lakes Basin Commission.

Given the federal government's significant financial involvement in flood and erosion protection and disaster relief, Michigan, Ohio, Pennsylvania and New York state hazard policy has been confined primarily to protection of state property, emergency measures and administration of submerged public lands. A most important observation is that, with the exception of Michigan, these states do not currently exercise any control over land use matters such as zoning bylaws or subdivision approval. The sentiment for home rule is very strong in these states. State involvement in coastal zone management, however, may modify eventually local control over land use planning.

Municipal Policy

There are 61 incorporated municipalities along the south Erie shoreline, within twelve counties and four

states. Typically, these municipalities have appealed to state and federal agencies for assistance during periods of high lake levels and storms on Lake Erie. In 1944, for example, following severe storms and flooding of drained farmland in the Reno Beach area of western Ohio, a local delegation appeared before a Senate subcommittee of the Committee on Commerce to request assistance.(129) More recently, the Pennsylvania House Appropriations Committee toured Presque Isle State Park at the invitation of local officials to examine damage from winter storms.(130) Often, local governments will issue resolutions requesting senior government action on flood and erosion problems. The Toledo Metropolitan Area Council of Governments passed such a resolution on October 16, 1974, requesting action on lake level regulation and a more integrated and coordinated approach by government agencies involved in Lake Erie flooding and erosion problems.(131)

In addition to requesting senior government assistance, however, municipalities on the south Erie shore have been involved in various aspects of the shoreline hazard problem. Some communities such as Detroit Beach, in Monroe County, Michigan, have built extensive shore protection works at local expense. In Michigan and Ohio, local assessment districts can be established to undertake shore protection works at local costs.(132) As well, in all four states, local municipalities can participate in cooperative flood and erosion control programs with the Corps of Engineers,

providing a share of costs and necessary land and easements. For example, during the recent high water period municipalities had to provide the necessary easements for Corps of Engineers Operation Foresight temporary dyking and will be required to remove the structures once the threat of flooding lessens.

Municipalities are greatly involved in emergency measures and flood fighting operations. Local civil defense units receive flood warnings from the National Weather Service and further disseminate this information and take action. The Monroe County Office of Preparedness has been particularly active in an emergency measures capacity along the Erie shoreline in Michigan. The County now operates the only automatic lake level warning device on the Great Lakes.(133)

In all four states, local governments are the primary locus of land regulation power. Only in isolated cases, however, have municipalities exercised zoning power in relation to flood and erosion hazards along Lake Erie. Port Clinton, Ohio, for example, has a lakefront zoning bylaw.(134) Eastlake, Ohio, introduced a moratorium on building permits along Lake Erie several years ago due to severe erosion problems.(135) With the introduction of the National Flood Insurance program, many municipalities will be enacting minimum hazard regulations to qualify for subsidized insurance coverage for property owners. As of February 29, 1976, all incorporated municipalities along the

south Erie shore, except for seven in Ohio and one in New York, were participating in the flood insurance program.(136)

Local health officials can exercise some control over development and in at least one area, Reno Beach, Ohio, refused to approve reconstruction of damaged homes along Lake Erie on the grounds that there was insufficient lot area left for septic systems.(137)

County planning boards in the various states have been encouraging local governments to adopt land regulations aimed at reducing future hazard damages. Their role, however, is one of preparing model bylaws and offering technical assistance on zoning and land use matters.(128) The decision to enact such bylaws remains with the individual municipalities.

Conclusions

Several conclusions can be drawn from an examination of policy formulation and expression on the north and south Erie shorelines:

First, administrative arrangements for dealing with flood and erosion hazards on the Lake Erie shoreline are highly fragmented. Tables 9 to 15 reveal no less than 54 international, federal, provincial, state, interstate and federal-state agencies involved in Erie shoreline hazards. The institutional structure is more complex on the south

Erie shore, with 9 federal, 22 state, 1 interstate and 1 federal-state agencies. There and 11 federal and 9 provincial agencies involved in flood and erosion hazards on the north Erie shore. Decision-making is further complicated by the existence of 31 incorporated municipalities on the north shore within 5 counties and regional municipalities, and 61 incorporated municipalities on the south Erie shore within 12 counties and four states. The existence of conservation authorities, local civil defense units, inter-municipal councils and special purpose drainage or erosion control districts further diversifies decision-making. Evidence suggests that administrative arrangements have become more complex in recent years. Many of the agencies involved in the recent high water period, such as the Small Business Administration, National Emergency Planning Establishment and Department of Regional Economic Expansion, did not have counterparts in operation during the 1951-1952 high water period. In Ontario, there has been some reduction in the number of municipalities involved, through municipal reorganization in Niagara and Haldimand-Norfolk. In general, however, the number of agencies involved in Erie shoreline hazards has increased in recent years.

Second, while administrative arrangements are unquestionably complex and fragmented, it is possible to identify some government agencies with a more central role in flood and erosion hazards. On the north Erie shore,

these 'core actors' include the Canada Department of the Environment and the Ontario Ministry of Natural Resources. On the south Erie shore, the U.S. Army Corps of Engineers, federal Departments of Housing and Urban Development and Commerce, Michigan Department of Natural Resources, Ohio Department of Natural Resources, Pennsylvania Department Environmental Resources and New York Deparment of Environmental Conservation are important agencies.

Third, in spite of the existence of 'core actors', it must be emphasized that single, comprehensive agencies are not available to deal with shoreline hazards. This is true when considering a single jurisdiction, Ontario for example, where many relevant functions are split among several agencies. It is also true when considering all three levels of government for a particular shoreline. For example, federal agencies have no direct control over land use regulation, which is a provincial and state function that has been delegated, in turn, to municipal governments. No single agency, therefore, can command a wide range of adjustments to the shoreline hazard problem.

Fourth, federal shoreline hazard policy in the United State is based in legislation and generally well defined. The Corps of Engineers, for example, is legislatively bound in terms of its response to Erie shoreline flooding and erosion. While this reduces, to some extent, ad hoc responses it also creates problems. The Corps can protect private property from flooding but not from erosion, when

the two hazards are often interrelated. In contrast, federal and provincial policy for dealing with north Erie shore hazards generally has not been well defined. This affords an opportunity for a flexible approach promoting a wide range of adjustments. Typically, however, ad hoc financial and other arrangements favouring structures have been made.

Fifth, government response to Erie flooding and erosion typically has been crisis generated. In this respect, the evolution of Lake Erie shoreline hazard policy lends credibility to the incrementalist theory of policy formulation. However, the existence of several fundamental policy initiatives such as the National Flood Insurance program and the U.S. Coastal Zone Management Act suggests that the mixed-scanning theory of policy formulation is a more appropriate model. While recognizing the incremental nature of many decisions, this theory views more fundamental and rational changes in policy as both possible and desirable.

And sixth, the crisis response nature of decision-making and the fragmentation of agency responsibility both within and among levels of government has facilitated a structural approach to the Erie shoreline hazard problem. Clearly, senior government has the financial power; local government has the land use regulation power. Senior governments, during times of crisis, are under considerable pressure to take some action.

Cost sharing arrangements for shore protection attractive to local governments have been an expedient solution. However, a recent broadening of the range of adjustments to shoreline hazards is evidenced by such programs as the U.S. National Flood Insurance program, Michigan shoreland management program and the Canada-Ontario Great Lakes Shore Damage Survey.

These conclusions suggest the need to examine in some detail a number of specific policies for dealing with flood and erosion hazards on the Erie shoreline.

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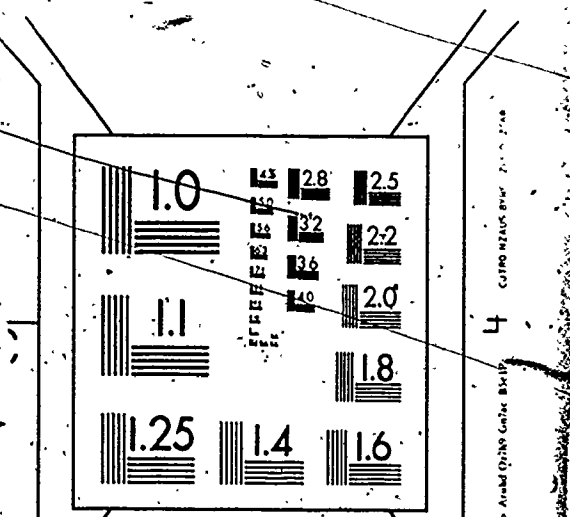

CHAPTER V

LAKE ERIE HAZARD POLICY EVALUATION

This Chapter evaluates Lake Erie flood and erosion hazard policy in terms of the environmental, socio-economic, political-administrative and technological-informational criteria specified in Chapter-II. These criteria are applied to a wide range of specific policies within the hazard loss reduction, hazard loss redistribution and do nothing public strategies.

Hazard Loss Reduction Policy

There are a great variety of options open to governments that aim to reduce hazard losses. These have been classified into measures that modify the hazard cause, modify the hazard and modify the loss potential.

Modify the Hazard Cause

This category of adjustments includes weather modification, channelization of the lake, diversions, lake level regulation and regulation of sand and gravel dredging, beach material removal and shore protection works.

Although weather modification has been practiced elsewhere with limited success in certain applications, large scale and long term control necessary to minimize lake level fluctuations or storms is not currently practical. Similarly, reducing Lake Erie to a narrow navigation channel or diverting flow around the Lake would not be feasible.

Some measure of lake level regulation for Lake Erie, however, is considered to be both technically possible and economically feasible. Lake Erie is already affected to a minimal degree by Lake Superior regulation, and three of the more realistic proposals of the International Great Lakes Levels Board are evaluated in some detail. An evaluation of lake level regulation is summarized on Table 16.

The purpose of lake level regulation is to control outflows from the Great Lakes, through the use of engineering works, to accomplish certain results, such as lower maximum levels, higher minimum levels or a reduced range of stage. Lower maximum levels can offer some relief from flood and erosion damages.

TABLE 16

LAKE LEVEL REGULATION (MODIFY THE HAZARD CAUSE)

Evaluation Criteria	
1. Are there impacts on the physical environment?	yes
2. Are there impacts on the biological environment?	yes--particularly on extent of wetlands
3. Are there impacts on aesthetics and recreation?	no--only in vicinity of control works
4. Is an environmental impact analysis required or other environmental guidelines specified?	yes
5. Are hazard damages reduced?	limited--little effect on storm damages
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no--100% Canadian and U.S. federal funding
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	yes
9. Is the policy sensitive to the concerns of affected individuals?	yes--generally acceptable to shore property owners
10. Is there provision for public input or appeal of decisions?	yes--public hearings
11. Is the policy crisis response or ad hoc?	yes--response to extreme low and high levels
12. Are there jurisdictional or administrative problems in applying the policy?	yes--regulation must be acceptable to both countries
13. Is the policy efficacious?	limited--little effect on storm damages
14. Are there guidelines to ensure efficacy?	yes--engineering considerations
15. Is the policy based on adequate information and techniques?	limited--long term weather forecasting needed
16. Is there provision for hindsight evaluation of the policy?	no

Over the years, many regulation schemes for the Lake Erie and the other Great Lakes have been proposed for navigation, power, water supply, flood control and other purposes. Since 1900, over 30 studies have been undertaken to determine the feasibility of regulating one or more of the Great Lakes.(1) To date, however, regulation has been accomplished on only two of the lakes. Lake Superior has been regulated under the supervision of the International Lake Superior Board of Control, a board of the International Joint Commission, since 1921 when a gated dam was constructed across the St. Marys River to compensate for power diversions. Lake Ontario has been regulated by the International St. Lawrence River Board of Control since 1958, with the completion of control works for the St. Lawrence Seaway and power project.

The International Joint Commission, established under the Boundary Waters Treaty of 1909, approves dams or other works affecting the levels and flows of boundary waters.(2) While the governments of Canada and the United States have not referred all such works to the International Joint Commission(3), it is likely that any plan of regulation for one or more of the Great Lakes would be referred to this international agency, as were the proposals for Lake Superior and Lake Ontario regulation.(4)

During extreme low levels on the Great Lakes in the mid 1960's, both governments requested that the International Joint Commission investigate lake levels and suggest what

action might be taken to bring about a more beneficial range of stage for domestic water supply and sanitation, navigation, fish and wildlife, recreation and other beneficial purposes.(5) The International Joint Commission established the International Great Lakes Levels Board in 1964; and this Board submitted its completed report to the Commission in 1973.

The International Great Lakes Levels Board found that a plan of regulation(SO-901), which coordinated the use of existing controls on Superior and Ontario, offered small net benefits at minimal cost.(6) This plan was used as a guide for emergency action undertaken by the International Joint Commission to alleviate flooding on the lower lakes in 1973. Beginning February 1, outflow from Lake Superior was reduced.(7) The International Great Lakes Levels Board also found that two plans for the combined regulation of Lakes Superior, Erie and Ontario(SEO-901 and SEO-42P) were feasible.(8) These three plans, SO-901, SEO-901 and SEO-42P, are evaluated in some detail.(9) Plans for regulating Lakes Huron and Michigan were found to be unfeasible.

Plan SO-901 is estimated to provide an average annual reduction in flood and erosion damages on Lake Erie of $386,000 and a total average annual economic impact on the Great Lakes of $2,370,000 at an average annual cost of $70,000. Environmental impacts are considered to be minor. Plan SEO-901 reportedly provides an average annual reduction

in Erie shoreline hazard damages of $2,513,000 and a total average annual economic impact on the Great Lakes of $6,361,000 at an average annual cost of $169,000. Environmental impacts, however, are greater and irreversible under this plan. Plan SEO-42P provides an estimated average annual reduction in flood and erosion damages on Lake Erie of $3,509,000 and a total average annual economic impact on the Great Lakes of $8,796,000 at an average annual cost of $450,000. Environmental impacts, particularly to reduced wetlands, are significant.

Any plan of regulation for Lake Erie will have some environmental impact. This impact will occur basically in two areas. First, any attempt to control the level of Lake Erie will necessitate changes in outflows through the Niagara River. Any increased frequency of low flows in the River may threaten fish and waterfowl habitat. Second, any attempt to reduce the range of stage of Lake Erie will affect the extent of wetlands bordering the Lake. Some authorities indicate the reduced maximum levels offer the opportunity to protect marshes from the Lake with dykes and other structures.(10) Thus, any plan of regulation reducing maximum levels would benefit controlled marshes, which are common in Western Ohio along Lake Erie. Other research, however, suggests that natural marshes are dependent on fluctuating lake levels, including extreme high and low levels, for their existence.(11) Most marshes on the north Erie shore are natural, rather than controlled.(12)

While lake level regulation can reduce flood and erosion damages, it should be noted that such regulation would likely encourage continued and even extended occupance of hazard lands. Most important, a reduction in maximum level will not eliminate flooding and erosion. Storms and other meterological disturbances will continue to raise levels far above any reductions that are feasible. This is illustrated by the damaging April, 1966, storm which raised the lake level at Toledo to 575.7 feet, exclusive of wave action. This level is some 5.5 feet above the mean level for April, 1966, of 570.2 feet.(13) Assuming that plans SO-901, SEO-901 and SEO-42P were in operation at that time, the mean level would have been 570.1, 570.0, and 569.8 feet respectively.(14) A short term fluctuation of 5.5 feet superimposed on these levels still would have resulted in considerable damage.

The three regulation plans seriously considered by the International Great Lakes Levels Board have impressive benefit-cost ratios ranging from 19.5:1 to 37.6:1, based on a discount rate of 7% over 50 years. It is instructive, however, to examine the distribution of benefits and costs. Benefits in the form of reduced flood and erosion damages constitute the largest portion of total benefits and these accrue mainly to American shore property owners due to the more intensively developed United States Great Lakes shoreline. Moreover, for both plan SEO-901 and SEO-42P,

which have the greatest effect on wetlands, Canada loses more wetland than the United States.

Three series of public hearings have been held on the International Great Lakes Levels Board study. An initial set of four hearings were held in May, 1965. Following the International Joint Commission's emergency regulation of Lake Superior, a further four hearings were held in May, 1973. A set of 13 hearings were held in October and November of 1974 to obtain public comment and reaction to the final report. Transcripts and news coverage of several of these most recent hearings reveal mixed opinion about lake level regulation.(15) Plan SEO-42P, providing the most extensive benefits to shore property interests appears to be widely supported by shore property owners, municipalities and politicians. Plan SEO-901 is particularly objectionable to many environmental groups.

Several jurisdictional problems associated with lake level regulation should be noted. First, under the terms of the Boundary Waters Treaty of 1909, both governments will have to agree to any plan of regulation for the Great Lakes, even if the governments bypass the International Joint Commission. Unilateral alteration of levels to the detriment of the other country is not permitted under Article III of the Treaty. Second, as was pointed out during the 1974 hearings, Article VIII of the Treaty establishes the following order of priority in dealing with boundary water problems: uses for domestic and sanitary purposes;

uses for navigation; and uses for power and irrigation. The Treaty does not appear to give the Commission specific mandate to consider shore property interests regarding flooding and erosion. Although the recent regulation study did consider these interests, some presentations at the hearings criticized the Treaty and Commission for giving precedence to navigation and power interests.(16) The popular conviction that high levels are encouraged by governments to satisfy navigation and power interests is reinforced. And third, the Province of Ontario presentation at the hearings raised an interesting jurisdictional point. Ontario has suggested that her administrative responsibility for the entire Canadian portion of the Great Lakes shoreline entitles her to some representation on the Boards of Control for Lake Superior and the St. Lawrence River.(17)

Man can induce and accelerate erosion along the shoreline in several ways, as outlined in Chapter III. There has been a debate, for some time, regarding the influence of offshore commercial sand and gravel dredging on shore erosion.(18) The removal of beach material has also been the subject of some debate. A most significant human influence on erosion, however, is navigation structures and shore protection works.(19) This is particularly true of jetties and groynes which trap sediment moving along the shore and accelerate erosion downdrift. All senior levels of government on Lake Erie attempt some regulation of shore protection and other coastal activities. Agencies involved

include the Canada Ministry of Transport, U.S. Army Corps of Engineers, Ontario Ministry of Natural Resources, Michigan Department of Natural Resources, Ohio Department of Natural Resources, Pennsylvania Department of Environmental Resources and New York Department of Environmental Conservation. The U.S. Army Corps of Engineers' permit program for activities in navigable waters is evaluated, in some detail, as an example of this type of government regulation. This evaluation is summarized on Table 17.

The purpose of Corps of Engineers permit program is to regulate the construction of shore protection works and other activities such as commercial sand and gravel dredging and land filling in Lake Erie and other navigable waters.

The Buffalo and Detroit Districts of the Corps of Engineers administer this program on Lake Erie. Administratively, the Corps has jurisdiction at and below elevation 572.8 feet on Lake Erie, which is the highest average monthly water level for the 1860-1970 period.(20) Activities at and below this elevation require a Corps permit, regardless of land or submerged land ownership.

In applying for a permit, shore property owners and other applicants must submit detailed descriptions and plans of the proposed activity.(21) The applicant must obtain any necessary state or local approvals for the proposed work and, if located within the coastal zone of a state having an approved coastal zone management program, must certify that the proposed work complies with that program. There is no

TABLE 17

PERMITS FOR ACTIVITIES IN NAVIGABLE WATERS (MODIFY THE HAZARD CAUSE)

Evaluation Criteria	
1. Are there impacts on the physical environment?	yes--policy can minimize adverse impacts
2. Are there impacts on the biological environment?	yes--policy can minimize adverse impacts
3. Are there impacts on aesthetics and recreation?	yes--policy can minimize adverse impacts
4. Is an environmental impact analysis required or other enviornmental guidelines specified?	yes
5. Are hazard damages reduced?	variable--policy can minimize damages
6. Is continued occupance of hazard land encouraged?	variable--indirectly, when structures are permitted
7. Do hazard land occupants bear most of the costs?	not applicable
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	no
9. Is the policy sensitive to the concerns of affected individuals?	variable
10. Is there provision for public input or appeal of decisions?	yes--public meetings and hearings
11. Is the policy crisis response or ad hoc?	no
12. Are there jurisdictional or administrative problems in applying the policy?	no--Corps of Engineers jurisdiction to 572.8 feet
13. Is the policy efficacious?	variable
14. Are there guidelines to ensure efficacy?	yes--permit evaluation based on various factors
15. Is the policy based on adequate information and techniques?	variable--knowledge of coastal processes variable
16. Is there provision for hindsight evaluation of the policy?	no

application fee, except for work involving the placement of fill material in navigable waters.

This policy can minimize the aesthetic, recreational, and environmental impact of shore protection and other work along the Erie shoreline through the careful consideration of proposed activities. Evaluation of each application by the Corps is based on a number of factors including conservation, economics, environmental concerns, historic values, fish and wildlife values, navigation, recreation, and water quality.(22) In general, no application will be accepted unless it is considered to be in the public interest. Of particular concern in the evaluation of applications, are the effects of the proposed activity on adjacent properties, wetlands, fish, wildlife and water quality, among other considerations. If the District Engineer believes that approval of the application may be justified but that the proposed activity would have a significant environmental impact, the Corps will prepare an environmental impact statement under the National Environmental Policy Act of 1969.

In addition to these general requirements and criteria, the Buffalo District of the Corps has a specific policy with respect to applications for the construction of groynes. This policy states that "since the detailed operation and overall effect of groins is not well understood, extreme caution should be exercised to preclude major downdrift erosion. At best, a preliminary understanding can be

obtained only after intensive study of the coastal processes in the proposed construction area".(23) The policy recommends that groynes not extend further than the three foot depth and the top should be only 1 foot above the expected high water level. Further, initial fill should be placed updrift of the structure a distance of two times the length of the groyne.

The permit program provides for public input. A public notice of all applications is issued by the Corps and any comments or objections to the application are passed on to the applicant for reaction or resolution. The District Engineer may hold a public meeting or hearing on the application if he feels it to be controversial. Public notices regarding applications for dredging and shore construction are sent to the Corps' Coastal Engineering Research Center in Virginia.

A letter of permission, rather than an permit, may be granted by the Corps when work is of a minor nature and objections and environmental impacts are not likely. The public notice is omitted when a letter of permission is issued.

All work authorized by permits granted under this program are inspected by the Corps to ensure compliance with the approved plans.

While the policy leaves much to the discretion of the District Engineers regarding evaluation of the applications and use of public input, the framework exists for a careful

consideration of activities in navigable waters. The Buffalo District has issued some 600 permits along the Erie shoreline since the 1972 high water period.(24) This compares with a total of over 1,600 permits issued by the Ohio Department of Natural Resources along the Lake Erie shoreline, suggesting that not all shore protection works constructed during the recent high water period have the required Corps of Engineers permit.

Effective regulation of shore construction and sand and gravel extraction can have some impact on alleviating accelerated erosion due to human interference in coastal processes. An opportunity is provided for government to suggest shore protection works less damaging to adjacent properties. It would appear, however, that present government permit procedures for shore protection works are not adequately enforced or do not consider coastal processes to any extent. The Buffalo District, Corps of Engineers, program does recognize problems inherent in groynes.

Modify the Hazard

Various structural and nonstructural adjustments are possible to modify the hazard in an attempt to reduce flood and erosion damages. Included among the structural adjustments are such "permanent" measures as seawalls, groynes, dykes, breakwaters, rip-rap, gabions and land

filling. Flood fighting involves temporary structural measures such as sand bagging and temporary dykes. Non-structural measures include beach nourishment and the protection of dunes and embankments with vegetation. All of the above adjustments can be used singly or in combination, such as groynes and beach nourishment.

Government agencies at all levels are responsible for the protection of public property. Senior levels of government have been particularly active in facilitating the construction of shore protection works. They have protected their own properties, for example parks and harbours. In addition, senior governments provide local governments with financial and other assistance for the construction of shore protection on municipal property. As well, under certain conditions, senior governments provide shore protection for private property, for example the Ontario Shoreline Property Assistance program and the Corps of Engineers Operation Foresight. Both federal governments on the Lake Erie shoreline assist property owners where federal navigation works contribute to erosion.

In general, structural attempts to modify the hazard are costly, not always effective in the long term, and often detrimental to the biophysical environment and shoreline aesthetics.(Figures 15, 16, 17 and 18) Moreover, structural adjustments encourage continued occupance of hazard land and, in cases where private property is protected, represent a significant public subsidy to shore property owners, many

FIGURE 15. View of a sheet steel groyne, showing accumulation of sand on one side of the structure. Shore protection works such as groynes interfere with sediment movement and can accelerate erosion of adjacent shore areas.

FIGURE 16. View of shore protection at Pelee, showing an A.R.D.A. breakwall built in 1973. This structure was built without any consideration for environmental implications, including effects on adjacent shore areas.

FIGURE 17 View of U.S. Army Corps of Engineer's "Operation Foresight" dyking in Monroe County, Michigan. These structures hamper recreational use of shorelines.

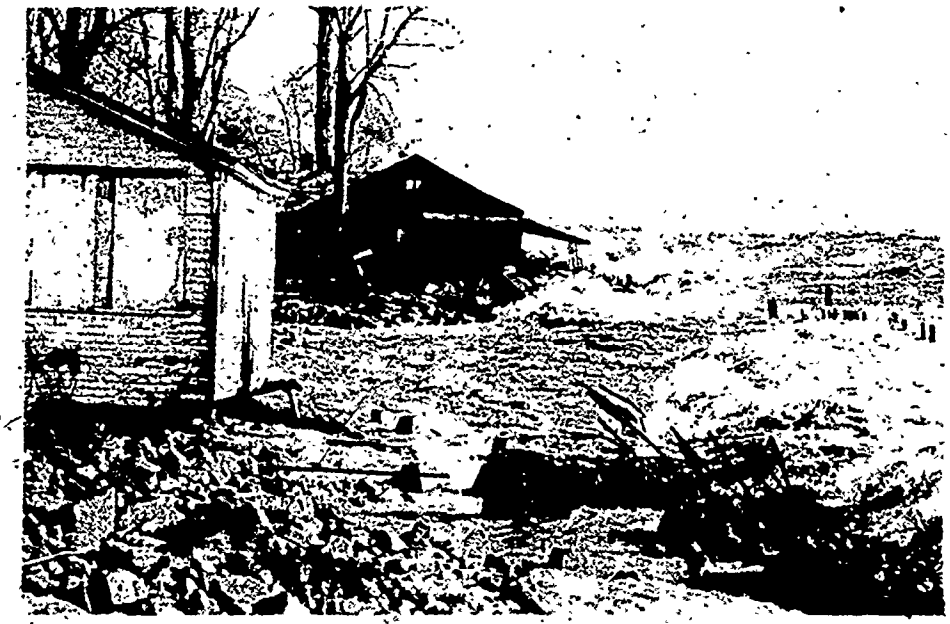

FIGURE 18 View of the Erie shoreline at Rondeau, showing recently constructed gabions and the remains of a wooden seawall and groynes built in 1952 with federal and provincial funding.

of whom have voluntarily located on the shoreline to derive certain benefits. Large scale applications of structural adjustments invariably generate conflict among local residents, environmentalists and government officials.

Six government programs providing structural shore protection on the Erie shoreline are evaluated in some detail. These are the A.R.D.A. Southwestern Ontario Dyking program, Ontario Shoreline Property Assistance program, Ontario Special Emergency Assistance program, Corps of Engineers Operation Foresight, Canada Public Works Shore Erosion Contributions program and Corps of Engineers Presque Isle Beach Erosion Control program. These programs represent a significant percent of the total government costs incurred during the 1972-1975 high water period on Lake Erie. Examples of public nonstructural adjustments that modify the hazard are rare on the Erie shoreline. The Corps of Engineers Presque Isle Beach Erosion Control program, which is partially nonstructural in its use of beach nourishment, is evaluated.

An evaluation of the A.R.D.A. Southwestern Ontario Dyking program is shown on Table 18. The purpose of this program is to provide financial assistance to municipalities for the construction of dykes protecting low-lying agricultural land along the Great Lakes shoreline. Under this program, the Canada Department of Regional Economic Expansion and the Ontario Ministry of Agriculture and Food each contributed 45% of the total cost of reconstructing

TABLE 18

A.R.D.A. DYKING IN SOUTHWESTERN ONTARIO (MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	yes--some trapping of longshore drift likely
2. Are there impacts on the biological environment?	yes--McGeachy's Pond enclosed by dyke and drained
3. Are there impacts on aesthetics and recreation?	yes--recreational access to lake inhibited
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	yes
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no--farmers subsidized 90% by senior governments
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	no
9. Is the policy sensitive to the concerns of affected individuals?	variable--not acceptable to some cottagers
10. Is there provision for public input or appeal of decisions?	limited
11. Is the policy crisis response or ad hoc?	yes
12. Are there jurisdictional or administrative problems in applying the policy?	yes--no provision for land acquisition
13. Is the policy efficacious?	yes
14. Are there guidelines to ensure efficacy?	yes--engineering report required
15. Is the policy based on adequate information and techniques?	limited--based on limited engineering considerations
16. Is there provision for hindsight evaluation of the policy?	no

dyking for municipal agricultural drainage schemes in Harwich Township, Kent County, and Mersea and Pelee Townships, Essex County, following the November 1972 flood. The municipalities were responsible for the remaining 10% of total costs and apportioned this share to benefitting private and public land owners under the terms of the Ontario Drainage Act.

The 90% federal-provincial subsidies for shore protection totalled $3,990,000 in the three municipalities, or $1,489,000 to Harwich Township, $1,209,000 to Mersea Township and $1,292,000 to Pelee Township.(25) The subsidies per acre of protected land were $1,081, $527 and $162, respectively, in Harwich, Mersea and Pelee Townships. These subsidies were made without the advantage of any benefit-cost or environmental studies. The Federal-Provincial Rural Development Agreement(A.R.D.A.) does require that project proposals include a listing of "the costs, the benefits, and assessments of the economic significance of each of the parts of the project".(26) There is no evidence, however, that this was done in conjunction with the A.R.D.A. Southwestern Ontario Dyking program.

It can be questioned whether the Federal-Provincial Rural Development Agreement was an appropriate funding vehicle for the 1973-1974 construction of dykes in Southwestern Ontario. The Agreement had to be amended to raise the maximum subsidy allowable from 66-2/3% to 90% of

total costs.(27) The Agreement was also amended to make flood protection by dyking and river channel improvement eligible for cost sharing. Moreover, the activities of the Canada Department of Regional Economic Expansion and the A.R.D.A. administration reportedly are aimed primarily at regional economic disparity and the plight of poorer rural Canadians.(28) The Agreement does not seem appropriate for funding large scale shore protection works in a relatively wealthy agricultural area. It is interesting to note, in this regard, that the Ontario Ministry of Agriculture and Food discontinued its A.R.D.A. drainage assistance program in Southwestern Ontario at the end of 1968 and began to concentrate its efforts in lower income Eastern Ontario.(29)

The A.R.D.A. Dyking program was administered by municipalities through the Ontario Drainage Act. This arrangement was not particularly suitable for administering a large scale shore protection program. There is no provision in the Drainage Act for the purchase of land. Consequently, an initial proposal to compensate 29 cottagers in Harwich Township for the removal of their houses to permit dyke construction would have resulted in the cottagers retaining title to the land and paying taxes on property of little benefit to them. Moreover, appeal procedures under the Act proved inadequate.(30) The cottagers involved had no effective recourse under the under the Act. In the Harwich case, only after an effective media campaign, did provincial A.R.D.A. officials intervene to

request that the municipality find an alternative location for the dyke.

Perhaps the most important issues surrounding the A.R.D.A. Dyking program relate to the cost sharing arrangement. Research on cost sharing for shore protection suggests that high senior government to local government sharing ratios can lead to inefficiencies.(31) It is possible that the 90% A.R.D.A. subsidy encouraged municipalities to adopt a more costly adjustment to the flood and erosion problem than they might have adopted otherwise. It is probable, for example, that emergency repairs of existing dykes might have prevented flooding. It is interesting to note that $125,000 in emergency dyke repairs in Harwich Township enabled the drainage scheme to survive major storms in the spring of 1973, more than a year before completion of the costly A.R.D.A. Dyking program. As well, significant differences in the per acre costs of protection $1,201 in Harwich, $585 in Mersea and $180 in Pelee, suggests that the shore protection constructed in Harwich Township may been been excessive.

A second issue relating to the cost sharing arrangement of the A.R.D.A. Dyking program was gross inequities that resulted. The cost sharing applied only to municipal drainage schemes, resulting in a situation were some farmers in those schemes received a subsidy up to $1,081 per acre while adjacent farmers received no subsidy at all. These

farmers in private schemes incurred heavy costs in protecting their land.(32)

An evaluation of the Ontario Shoreline Property Assistance program is summarized on Table 19. This program provides loans to shore property owners for the construction of shore protection works and repair of flood or erosion damaged buildings. It is a program that aims to modify the hazard and spread the losses, to the extent that provincial funds are available at less than conventional lending rates. The Shoreline Property Assistance program provides a procedure whereby municipalities may borrow from the province for the purpose of making loans to owners wishing to rehabilitate and protect their shoreline property as a result of flooding, erosion or the action of ice. Regulations limit the amount of money a property owner can borrow up to 90% of the total cost of building repairs to a maximum $20,000 and $150 per shoreline foot for protection works.(33) Loans are repayable as municipal taxes over 20 years at 8% interest.

To make loans available to property owners, a municipality must first pass a bylaw authorizing borrowing of funds from the province. The approval of any loan application by a shore property owner is at the discretion of the municipal council, whose decision is final. The municipality must appoint a competent inspector to assess the need and adequacy of the proposed work and its compatibility with adjacent property.

TABLE 19

SHORELINE PROPERTY ASSISTANCE PROGRAM(MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	variable--especially where groynes are constructed
2. Are there impacts on the biological environment?	variable
3. Are there impacts on aesthetics and recreation?	variable
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	variable
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	yes--loans are repayable over 20 years
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	no
9. Is the policy sensitive to the concerns of affected individuals?	yes--acceptable to shore property owners
10. Is there provision for public input or appeal of decisions?	limited
11. Is the policy crisis response or ad hoc?	yes--response to fall 1972 storm
12. Are there jurisdictional or administrative problems in applying the policy?	no
13. Is the policy efficacious?	variable
14. Are there guidelines to ensure efficacy?	limited--municipality appoints inspector
15. Is the policy based on adequate information and techniques?	variable
16. Is there provision for hindsight evaluation of the policy?	no

From the inception of this program in April, 1973, to March, 1976, only 8 of 30 municipalities along the north Erie shore had approved loans totalling $337,200 to property owners.(34) An additional 5 municipalities had passed the necessary borrowing bylaw but had not yet approved loans. Some 57% of all municipalities had not passed the borrowing bylaw to enter the program. Most of these municipalities are located in Elgin and Kent Counties where the predominant shoreline is high till bluffs and not extensively developed in cottages or homes. However, some municipalities with significant cottage and permanent residential development along their shores have been reluctant to become involved in the program because of potential burden should protective works fail and properties be abandoned. The reluctance of some municipal councils to become involved in the program is reflected in an unawareness of the program among many shore residents. In the Rondeau area, for example, only 9% of the coastal population was aware of the Shoreline Property Assistance program.(35) Municipal councils and clerks in some areas are not communicating the availability of loans to potential users of the program. This lack of knowledge of the program is unfortunate, as a significant number of shore property owners in the Rondeau area indicated the need for a loan program rather than outright grants.(36) The Shoreline Property Assistance program appears to be aimed at a recognized need.

While the program, by providing loans rather than grants, has advantages, a number of problems are associated with its administration. One basic problem concerns the municipality's ability to appoint a competent inspector, who in some cases might be a building inspector or road engineer, someone with little expertise in the technical matters of shore protection. This problem can be critical, as some forms of shore protection, such as groynes, may have a substantial impact on erosion of adjacent properties. Fortunately, the Ministry of Natural Resources offers an Extension Service program providing engineering advice on shore protection for those who are aware of the program and wish to use it. As well, groynes and some other shore protection works would likely require a provincial and possibly a federal permit and adjacent property owners would have an opportunity to comment on the proposed works. As previously indicated, however, evidence suggests that these permit programs are not being extensively enforced along the Erie shoreline.

Another problem associated with the Shoreline Property Assistance program is that it encourages continued occupance and protection of hazardous properties. The program does not permit relocation or flood proofing of buildings before they are damaged by flooding or erosion. Relocation has been allowed under the program only once on Lake Erie, and only after erosion had seriously undermined the foundation.(37) In the Village of Erieau, a homeowner was

refused a loan to relocate his home further back on his lot to prevent flood damages.(38) To be eligible under the Shoreline Property Assistance program, this cottager would first have to suffer flood damages before he could take action. The program emphasizes after-the-fact repairs rather than preventive action.

An evaluation of the Ontario Special Emergency Assistance program is summarized on Table 20. This program, administered by the Ministry of Treasury, Economics and Intergovernmental Affairs, assists municipalities along the Great Lakes shoreline with works of an emergency nature, repairing damage to, or preventing flooding or erosion of, facilities for which the municipalities are directly responsible. Ministry guidelines specify the eligible works a municipality can undertake, with a 80% provincial grant.(39) These works include repairs and improvements to municipal roads and dykes necessary because of flooding and erosion, pumping off flood waters from municipal property, temporary flood protection for municipal property, erosion protection for roads and works providing immediate and temporary access where road access is eliminated and early repair is not possible.

This program provides municipalities with the means to maintain essential services during times of crisis due to Great Lakes flooding and erosion. The program has been used by 20 of 30 municipalities along the north Erie shore. Provincial grants from the program's inception in April 1973

TABLE 20

SPECIAL EMERGENCY ASSISTANCE PROGRAM(MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	variable
2. Are there impacts on the biological environment?	variable
3. Are there impacts on aesthetics and recreation?	variable
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	yes
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no--80% provincial grant
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	no
9. Is the policy sensitive to the concerns of affected individuals?	yes--generally acceptable to shore property owners
10. Is there provision for public input or appeal of decisions?	no--municipal council decision
11. Is the policy crisis response or ad hoc?	yes--response to fall 1972 storm
12. Are there jurisdictional or administrative problems in applying the policy?	no
13. Is the policy efficacious?	variable
14. Are there guidelines to ensure efficacy?	limited
15. Is the policy based on adequate information and techniques?	variable
16. Is there provision for hindsight evaluation of the policy?	no

to March 1976 total $1,900,263.(40) Use of the program has been widespread along the Lake, with the exception of Elgin County where human encroachment along the highly erodible bluffs has not been extensive. No estimate of the benefits of this program is available, but it is likely that cost-effectiveness varies considerably among the various projects. There are no benefit-cost or environmental guidelines under the program to ensure effectiveness and efficiency.

While the program is specifically directed to the maintenance of municipal services and the protection of municipal property, it is possible that a municipality could use funds to protect private property, which is not directly eligible. For example, the Village of Erie Beach may construct large groynes along the shore. By locating these structures on a number of road ends in the Village, the province absorbs 80% of the cost. If the groynes are built in front of homes and cottages, the only assistance available would be loans under the Ontario Shoreline Property Assistance program. It is possible, therefore, without adequate inspection and enforcement of the guidelines under the Special Emergency Assistance program, that public funds could be used to protect private property. Such a situation did materialize in Colchester South Township, where groynes were located on road allowances rather than directly in front of private properties.(41) As well, Howard Township misused over $2,000 under this program

by protecting private agricultural land.(42) Program guidelines specify that provincial approval of grants will incorporate a field evaluation of the works.(43) It is not known, however, to what extent the guidelines are being enforced.

The original guidelines under this program excluded erosion control works, specifically "retaining walls, groynes and breakwalls".(44) The guidelines were subsequently modified to include these more permanent works. In this way, the province was able to contribute about 57% of the total cost of a federal-provincial-municipal breakwall in Port Burwell. The breakwall protects a road that disappeared about 10 years ago.(45) The protection of about 14 cottages and homes, however, appears to underlie the construction of this $448,000 breakwall. The Special Emergency Assistance program apparently has been used, in the Port Burwell example, as a convenient means of funding the local share of shore protection of private property under the federal policy of contributing to the protection of private property suffering accelerated erosion due to a federal navigation structure. The federal government contributed about 29% of the total costs of the Port Burwell breakwall under this policy. It is questionable whether the Special Emergency Assistance program is an appropriate vehicle for funding the local share of this breakwall, given the program's stated guidelines on eligible costs and its emphasis on works of an emergency and temporary nature.

A final issue concerning this program relates to the emphasis placed on the maintenance of roads and other services in highly hazardous areas. It may be more efficient and effective in the long term to relocate facilities in some areas. Existing cost sharing arrangements, however, do not encourage relocation. The Ontario Ministry of Transportation and Communications pays 50% of the costs of road construction and maintenance under the Public Transportation and Highway Improvement Act. Relocated roads could be constructed under this program. However, the Special Emergency Assistance program provides an 80% subsidy for the maintenance of roads in hazardous areas, making this program more attractive.

An evaluation of the Operation Foresight program in Michigan, Ohio and New York is summarized on Table 21. This U.S. Army Corps of Engineers program provides temporary flood control structures to protect private and public property from Great Lakes flooding. The North Central Divison of the Corps implemented Operation Foresight in December 1972, following the devastating November floods.(46) Operation Foresight consists of two programs, both requiring initiative from local governments. Under the self-help material-technical assistance program, the Corps provided the materials and technical advice necessary for the construction of temporary dykes. Local governments arranged labour, sometimes on a volunteer basis, to construct the dykes. Under the contract program, the Corps

TABLE 21

OPERATION FORESIGHT(MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	variable--protection works are temporary
2. Are there impacts on the biological environment?	variable--protection works are temporary
3. Are there impacts on aesthetics and recreation?	yes--recreational access to lake inhibited
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	yes
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no--100% federal funding
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	limited
9. Is the policy sensitive to the concerns of affected individuals?	variable--not acceptable to some property owners
10. Is there provision for public input or appeal of decisions?	limited
11. Is the policy crisis response or ad hoc?	yes--crisis response application of existing policy
12. Are there jurisdictional or administrative problems in applying the policy?	yes--can protect from flood hazard only
13. Is the policy efficacious?	yes--some failure of protection works
14. Are there guidelines to ensure efficacy?	limited
15. Is the policy based on adequate information and techniques?	variable--based on 5 foot design wave
16. Is there provision for hindsight evaluation of the policy?	no

designed and paid 100% of the costs of construction of shore protection. Both programs required initiation by local governments, who provided a general plan for flood protection, rights of way over private property and removal of temporary structures after the flood danger had passed. The works were designed to withstand 5 foot waves, or a 10 year storm, and were intended to be removed in about two years after construction.

The Corps undertook projects only where four criteria could be met: the value of property protected was greater than costs of protection; the temporary protection was practical from an engineering viewpoint; the initiative for protection came from the local government or incorporated public authority; and the protection was for flooding and not erosion.(47)

Operation Foresight was applied in 16 areas along the Erie shoreline in Michigan, Ohio and New York principally during the spring and summer of 1973. Most of the construction in terms of number of projects and costs was concentrated in the western basin of the Lake, along the Monroe County, Michigan, and Lucas County, Ohio, shoreline. The potential for flooding is greatest in this area. Total construction cost for the 16 projects on Lake Erie was $11,133,115.(48) Some $1,161,400 in repairs were necessary. For three of the larger projects in the highly harzardous western basin, Luna Pier, Toledo and Reno Beach, $19,500,000 in potential property damage reportedly was prevented at a

cost of $6,048,000, resulting in benefit-cost ratio of 3.2:1.(49) This assumes, however, that all property would be destroyed in the event of a flood and that pre-Operation Foresight protection would not be effective. For the only project constructed in the eastern basin, Van Buren Point, New York, it was estimated that $46,000 in potential damages were prevented at an expenditure of $80,700, resulting in a benefit-cost ratio of only .6:1. While no estimate of actual benefits has been made, some of the Operation Foresight dykes have been credited with reducing flood damages during the March-April 1973, June 1973 and April 1974 floods.(50)

While it is generally recognized that the Operation Foresight projects have been reasonably effective in reducing flood damages, a number of problems are associated with them. First, many of the projects have required maintenance and there has been some controversy over whether the Corps of Engineers or the local governments should be responsible for repairs.(51) While it is a Corps policy to require local interests to maintain the dykes, it is also a Corps policy to repair federal flood control works where these are threatened with imminent failure. In at least several cases, local governments have not made repairs in the hope that the Corps would step in with emergency repairs, which sometimes have been extensive. At Eastlake, Ohio, for example, subsequent repairs were significantly higher than the initial construction cost. The maintenance

problem is partially a result of the 5 foot wave design criteria used. The dykes were built to last two years, while lake levels are predicted only 6 months in advance. Storms in June 1973 and April 1974, for example, were severe enough to cause the failure of Operation Foresight dykes in Monroe County, Michigan, and threaten other projects.(52).

A second problem with the Operation Foresight program concerns its acceptability to many property owners and some local governments. Controversy centred on the local government's responsibility under the program for providing rights of way and removal of structures after the flood danger had passed. Some local governments did not wish to assume such responsibilities. Some of those that did, such as Luna Pier and La Salle Township in Michigan, were forced to seek court action to compel a number of property owners to sign easements to allow construction of the dykes on their properties.(53) In the Luna Pier situation, some 125 property owners had objected to the Operation Foresight project, mainly for aesthetic and recreational access reasons. A court decision requiring the City of Luna Pier to remove the structures after the flood danger passed and to pay property owners for any damages incurred in the construction and removal of dykes, removed much of the opposition to the project. Other sources of objection to the dykes included the destruction of buildings in the path of dyke construction and interference with commercial operations such as boat rental and fishing businesses.(54)

A third problem with the Operation Foresight program was the duplication, in at least one instance, of the emergency dyking with a permanent program of flood protection. In the Point Place suburb of Toledo, the $1,785,000 Operation Foresight project was undertaken while a previously authorized $960,000 permanent Corps of Engineers flood control project was awaiting funding by Congress. Under the permanent plan, the City of Toledo would pay $46,500 in rights of way costs, and benefitting property owners would pay $173,000, or about 18% of the total cost, with the Corps contributing the remainder.(55) Environmental impact, benefit-cost and detailed pre-construction design studies would be required under the permanent flood control project, unlike the Operation Foresight project. This raises a serious issue with temporary or emergency flood protection, which may be more attractive in some cases to local interests given the different cost sharing arrangements and other requirements. Conservation interests have raised this issue elsewhere, in conjunction with emergency work by the Soil Conservation Service of the U.S. Department of Agriculture.(56) Without reasonable limits or criteria on the amount of emergency flood control work that is done, it is conceivable that this type of work might become a locally attractive substitute for more permanent protection or other nonstructural solutions.

A final problem concerns the difficulty, in some cases, in distinguishing flooding from erosion problems. This is an important consideration, as the Corps of Engineers is authorized to protect private property from flooding but not erosion. Some areas along the Erie shoreline were not eligible for Operation Foresight protection because of this requirement and in other areas there was difficulty determining eligibility given the often interrelated nature of flood and erosion hazards.(57)

An evaluation of the Canada Department of Public Works Shore Erosion Contributions program is summarized on Table 22. Under this program, the Department contributes up to 50% of the total costs of shore protection works for property suffering erosion due to commercial navigation or federal navigation structures. Affected property owners must apply to the Department submitting a plan of proposed protection.(58) A Department engineer then undertakes a site inspection to confirm that erosion is occurring due to commercial navigation or a federal navigation structure. Shore protection proposed by the applicant must meet with Department of Public Works approval, the applicant undertakes construction and the Department reimburses a portion of the total costs after a final inspection.

Since 1966, when this program was introduced, there have been 71 applications from property owners along the north Erie shore.(59) Some 18 applications have been approved, and grants of 25% to 39% of total costs have been

TABLE 22

SHORE EROSION CONTRIBUTIONS (MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	variable--especially where groynes are constructed
2. Are there impacts on the biological environment?	variable
3. Are there impacts on aesthetics and recreation?	yes
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	variable
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	variable--federal contribution up to 50% of costs
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	limited--site inspection by federal engineer
9. Is the policy sensitive to the concerns of affected individuals?	yes--generally acceptable to shore property owners
10. Is there provision for public input or appeal of decisions?	no
11. Is the policy crisis response or ad hoc?	yes--crisis response application of existing policy
12. Are there jurisdictional or administrative problems in applying the policy?	no
13. Is the policy efficacious?	variable
14. Are there guidelines to ensure efficacy?	yes--limited engineering considerations
15. Is the policy based on adequate information and techniques?	limited
16. Is there provision for hindsight evaluation of the policy?	no

provided for 15 of these applications. All successful applications have originated from Port Stanley and Port Burwell, where the federal government has admitted liability for erosion due to navigation structures. In addition to the municipalities of Port Stanley and Port Burwell, there were 13 private property owners who received grants. Total grants disbursed under this program to the end of 1975 amounted to $166,210.(60) Some $129,472 was granted to the Village of Port Burwell for a quarry stone breakwall, while the remainder of the grants ranged from $207 to $8,522.

While there are no provisions for environmental impact or benefit-cost studies, the provision for site inspection by the Department of Public Works does offer an opportunity to provide advice to property owners on the most suitable protection for any particular area. This is done to ensure that both public funds and those of the applicant are spent wisely.(61) It has been suggested that shore protection provided under this program has reduced erosion, particularly in Port Stanley. The breakwall at Port Burwell "appears to be effective but has been in only a year or two".(62)

While this program is established, rather than ad hoc, its application is crisis response in the sense that applications appear to be motivated, in part, by high lake levels and concommitant increases in erosion. The program appears inflexible in that it provides federal assistance for shore protection only. As this program has been applied

to the Erie shoreline, this program has made no provision for assistance in buying out endanagered properties or in relocation.(63) However, the Department of Public Works has used relocation on the St. Lawrence River near Sept-Isle, where several families were relocated as an alternative to protecting their properties.(64) This suggests that there may be scope for use of nonstructural techniques where these are more efficient in the long term.

An evaluation of the Presque Isle Beach Erosion Control project is summarized on Table 23. This project involves an attempt to control erosion of Presque Isle State Park through artificial beach nourishment and shore protection works.

In response to high water conditions and serious erosion of the Presque Isle peninsula, the Commonwealth of Pennsylvania and the federal government through the Army Corps of Engineers entered into a cooperative beach erosion control project. This project, undertaken in 1955 and 1956, involved the construction of seawalls, bulkheads and groynes, as well as the placement of sand fill. A subsequent agreement in 1960 provided for beach nourishment for a period of 10 years, ending in 1971. A third project is currently under consideration, involving the construction of a partial breakwater system along the length of the peninsula.

The persistent erosion problem at Presque Isle appears to be partially a result of reduced littoral drift. Shore

TABLE 23

PRESQUE ISLE BEACH EROSION CONTROL PROJECT(MODIFY THE HAZARD)

Evaluation Criteria	
1. Are there impacts on the physical environment?	yes--groynes modify longshore drift
2. Are there impacts on the biological environment?	yes--excavation of sand
3. Are there impacts on aesthetics and recreation?	yes
4. Is an environmental impact analysis required or other environmental guidelines specified?	yes--for work after 1970
5. Are hazard damages reduced?	limited
6. Is continued occupance of hazard land encouraged?	yes--although occupance mainly nonstructural
7. Do hazard land occupants bear most of the costs?	no--federal share 70% after 1962
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	yes
9. Is the policy sensitive to the concerns of affected individuals?	variable--local pressure for more permanent solution
10. Is there provision for public input or appeal of decisions?	yes--public hearings
11. Is the policy crisis response or ad hoc?	no--application of established federal policy
12. Are there jurisdictional or administrative problems in applying the policy?	no
13. Is the policy efficacious?	limited--only retarding erosion problem
14. Are there guidelines to ensure efficacy?	yes--engineering considerations
15. Is the policy based on adequate information and techniques?	limited--only partial understanding of processes
16. Is there provision for hindsight evaluation of the policy	yes--periodic surveys and monitoring

protection works and harbour works to the west of the peninsula, notably at Fairport, Ashtabula and Conneaut, Ohio, trap a significant portion of the sediment in motion along the shore.(65)

The initial 1955-56 project involved the construction of seawalls and groynes along the neck of the peninsula and the placement of 4,200,000 cubic yards of sand. Total cost was $2,452,269, of which the federal government assumed 33-1/3%.(66) Sand for the artificial beach nourishment was excavated from several areas on the peninsula. The 1953 engineering report estimated the required annual rate of nourishment at 20,000 cubic yards.(67) Experience has shown that the initial project failed badly. The sand used to nourish the beaches was too fine, having an average diameter of .20 mm compared with natural beach sand diameter of .35 mm.(68) As a result, much of the sand was lost offshore. As well, subsequent surveys and reports have shown that the required rate of nourishment is in the order of 10 times the original estimate. Coastal processes operating in the Presque Isle area have not been well understood. It should be stressed, however, that Corps of Engineers monitoring and post project evaluations have provided valuable insight into way the project failed and how to correct deficiencies.

The second project involved periodic beach nourishment over a ten year period ending in 1971. Total cost was $1,903,062, and the federal contribution was increased in 1962 from 33-1/3% to 70%.(69) Several applications of

coarse sand proved to be somewhat more successful in maintaining beaches; however, surveys have shown that supplies of suitable sand in the Presque Isle area are limited.(70)

By 1973, beaches at Presque Isle were so depleted that the Corps of Engineers undertook emergency sand placement to protect the groynes and seawalls built under previous projects. As well, the Pennsylvania Department of Environmental Resources undertook the construction of shore protection works to prevent undermining of roads in several areas of the Park. In response to a request from the State, the federal government has authorized a five year extension of the cooperative project.(71) This will mainly involve additional placement of sand.

Local residents have repeatedly requested a more 'permanent' solution to the erosion problem at Presque Isle, and Corps of Engineers has responded with a review of previous projects and a recommendation for a partial breakwater scheme. High annual maintenance costs and recurring threats to facilities have been cited as reasons for a more permanent solution.(72) The partial breakwater system would trap sand in the lee of breakwaters and increase erosion in adjacent areas. Annual maintenance would be required to move any sand from areas of accretion to areas of erosion. An important advantage to this system is claimed in that it reduces the dependence on an external source of beach building sand. As well, the structure would

be about 1000 feet offshore and not interfere with beach recreation. This partial breakwater sytem, if authorized, is expected to cost about $21,203,000, with the federal government assuming 70% of the costs.(73)

Three broad issues continue to surround the cooperative beach erosion control project at Presque Isle. The first might be termed social and concerns the need for preserving the recreational value of the peninsula. Newspaper coverage and public response at hearings on the project suggests that most local people have strong feelings about the need to preserve the State Park for recreational use. Some 3,500,000 people visit the Park annually.(74) In light of strong local pressure for preservation of the peninsula, a "do nothing" approach is not likely to be socially acceptable.

A second issue concerns the economic justification for massive expenditures on beach preservation. The City of Erie estimates the Park is worth $60,000,000 annually to the area economy.(75) However, benefit-cost studies on the existing and proposed projects have not shown particularly high ratios of benefits over costs. The 1960 project had an estimated benefit-cost ratio of 1.3:1.(76) The proposed partial breakwater is estimated to have a benefit-cost ratio of 2.0:1.(77) Given the uncertainties associated with benefit-cost estimations, these ratios are not convincing evidence of economic justification. This is particularly

important, as several other alternatives to the partial breakwater are considerably less expensive.

A final important issue concerns the environmental impact of existing and proposed projects. Previous projects, with their emphasis on artificial beach nourishment, have probably supplied a greater than natural amount of sand to the tip of the peninsula. This is an area of prime ecological concern, for it is at the tip of the sand spit where ecological processes such as succession can be best viewed. This greater than normal availability of sand has not had a significant impact, other than to accelerate certain processes. Excavation of sand on the peninsula to supply the required material for beach nourishment has had some impact, however, particularly in reducing wetland habitat. One of larger borrow areas is now used as a marina. The most significant ecological concern arises from the proposed 'permanent' protection for Presque Isle. Some of the alternatives suggested, such as a full breakwater, groyne system, and sand recirculation system, would effectively reduce or terminate successional processes at the tip of the peninsula by cutting off the littoral drift to this area.(78) The partial breakwater system would presumably allow sufficient sand to reach the tip that successional processes would likely not be terminated. However, the environmental impact statement on the proposed partial breakwater concludes that "the rate of sandspit formation and possibly dune formation will be reduced to an

unpredictable level...if this happens, the ecological uniqueness of Presque Isle will be lost".(79) It is imperative that the consequences of any proposed solution be fully understood. It has been estimated that Presque Isle has migrated from west to east about 3 miles during the past 600-700 years.(80) Presque Isle is a highly dynamic system of beaches, dunes and wetlands. Experience has shown the weakness of knowledge of coastal processes in this area and suggests that any proposed action to reduce erosion must be based on adequate information.

Modify the Loss Potential

This diverse category of adjustments includes flood forecasting and warning, evacuation and other emergency measures, flood proofing, relocation, land use change to damage tolerant uses and a variety of regulations including zoning, subdivision, sanitary and building regulations.(Figures 19 and 20) As well, governments can purchase land and buildings, determine and disseminate information on degree of risk and use tax incentives to encourage private measures to reduce loss potential or keep land in damage tolerant uses.

The U.S. Department of Commerce National Weather Service and Canada Department of Environment are key agencies for flood and severe erosion forecasts on Lake Erie. An evaluation of Environment Canada's Lake Level

FIGURE 19 View of the Erie shoreline at Port Burwell, showing the foundation of a cottage that has been relocated. Relocation and structural set-backs are possible adjustments to shoreline erosion.

FIGURE 20 View of the marsh boardwalk at Point Pelee. Many recreational uses of hazardous shorelines are damage tolerant. By acquiring hazardous shore areas, governments can provide recreational access and reduce flood and erosion damages.

Advisory and Warning Service is summarized on Table 24. This system attempts to predict short term high lake levels and disseminate flood warnings to appropriate agencies and shore property owners. The Lake Level Advisory and Warning Service at the Toronto Weather Office forecasts 6 to 12 hours in advance whether levels are likely to exceed the daily average by two feet. Probable wave heights are added to this predicted wind set-up or seiche to determine potential inundation levels.

For Lake Erie forecasts, water level information is obtained hourly from automatic gauges at Port Colborne and Point Pelee. Warnings of potential inundation levels are sent by telex to a number of agencies including the Ontario Ministry of Natural Resources in Queen's Park, Fonthill and Chatham, the Ontario Provincial Police headquarters in Downsview, the Canada Centre for Inland Waters in Burlington, satellite weather offices in Kitchener, Hamilton, London and Windsor and to Broadcast News, which disseminates the warnings to radio stations.(81)

Accurate flood forecasting and timely warnings have the potential of reducing flood damages along the Erie shoreline and elsewhere. Warnings sometimes provide property owners with an opportunity to undertake emergency measures to protect their property. This might range from simply removing valuable possessions to flood fighting procedures such as sandbagging. A number of factors, however, complicate the accurate forecasting and dissemination of

TABLE 24

FLOOD FORECASTING AND WARNING (MODIFY THE LOSS POTENTIAL)

Evaluation Criteria	
1. Are there impacts on the physical environment?	no
2. Are there impacts on the biological environment?	no
3. Are there impacts on aesthetics and recreation?	no
4. Is an environmental impact analysis required or other environmental guidelines specified?	not applicable
5. Are hazard damages reduced?	limited--only where individuals or agencies act
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	not applicable
9. Is the policy sensitive to the concerns of affected individuals?	yes--generally acceptable to property owners
10. Is there provision for public input or appeal of decisions?	not applicable
11. Is the policy crisis response or ad hoc?	yes--response to fall 1972 storm
12. Are there jurisdictional or administrative problems in applying the policy?	yes
13. Is the policy efficacious?	limited
14. Are there guidelines to ensure efficacy?	no
15. Is the policy based on adequate information and techniques?	limited
16. Is there provision for hindsight evaluation of the policy?	no

warnings. First of all, Lake Erie, a shallow lake with a long fetch and northeast-southwest orientation, is particularly susceptible to short term variations in lake levels. Seiches due to differences in atmospheric pressure over the surface of the lake are particularly difficult to predict. A second complicating factor relates to seasonal variations in the probability of severe storms. November and March are particularly susceptible to severe storms. An important implication here is that flooding is most likely to occur during the fall and spring, when seasonal residents are not available to take advantage of any flood warning. For example, few cottagers were around during the November 1975 flood in the Long Point-Turkey Point area.(82) Also important here is the likelihood of snow, rain or sleet to complicate emergency measures or evacuation.

The Lake Level Advisory and Warning Service was initiated in February, 1973, following the devastating November 1972 floods on the lower Great Lakes. Prior to this service, there was no special forecast or warning for lake levels, other than the regular wind and weather forecast.(83) The service likely will be continued. Although the Atmospheric Environment Service of Environment Canada, which operates the service, contacts a number of agencies, there is no direct contact with the news media. An arrangement has been made with Broadcast News that warnings will be transmitted by Broadcast News to local media without delay or edition of the warning. No

evaluation of the Lake Level Advisory and Warning Service has been undertaken, although some information supplied by the Windsor and Essex Emergency Measures Organization suggests that the service provided timely and useful warnings on at least several occassion.(84) It is also possible to comment on the effectiveness of flood warnings in general.

Any warning system basically consists of three parts: evaluation of the hazard threat or forecasting; dissemination of the warning; and response to the warning.(85) A great variety of agencies and individuals are in this system and a failure in any part of the system can negate the entire warning system. For the north Erie shoreline, the first part of the system, forecasting, is the responsibility of Environment Canada. This agency, along with a variety of other agencies such as the Ontario Ministry of Natural Resources and the Ontario Provincial Police are responsible for the second part of the system, dissemination of the warning. There is evidence that some local agencies, such as the Windsor and Essex County Emergency Measures Organization, receive the warning, in this particular case, from the Windsor Weather Office.(86) It is not at all clear, however, how many shore property owners receive the warning. Cottagers are particularly difficult to reach. The third part of the system, the response, involves a variety of agencies and shore property owners. Again, there is evidence that some local agencies

effectively use the warning, while it is not clear that many shore property owners respond to the warnings.

Research elsewhere suggests that flood forecasting and warning systems can be highly cost-effective, that is, considerable property damage can be avoided through the use of timely and accurate warnings of impending disasters at relatively little cost for the operation of the warning system. An important constraint on warning systems, particularly at the local level, is that they are used infrequently.(87) This is of particular consequence for Lake Erie, where long periods of relatively low lake levels seem to minimize the need for such a system. Another constraint on warning systems is the behaviour of individuals towards warnings and the complex social and pyschological factors that influence response or nonresponse to warnings. This will probably continue to be the least understood part of the warning system. There is likely to exist a certain proportion of the affected population that will ignore a warning, no matter how timely or useful.

A very important category of adjustments which seek to modify the loss potential are those that regulate construction in hazardous areas. In this respect, Michigan is the only jurisdiction on Lake Erie with an explicit shoreline policy of this type.

An evaluation of the Michigan Shorelands Management program is summarized on Table 25. The Michigan Shorelands

TABLE 25

MICHIGAN SHORELANDS MANAGEMENT PROGRAM (MODIFY THE LOSS POTENTIAL)

Evaluation Criteria	
1. Are there impacts on the physical environment?	yes--policy can minimize adverse impacts
2. Are there impacts on the biological environment?	yes--policy can minimize adverse impacts
3. Are there impacts on aesthetics and recreation?	yes--policy can minimize adverse impacts
4. Is an environmental impact analysis required or other environmental guidelines specified?	yes--various regulations specified
5. Are hazard damages reduced?	yes
6. Is continued occupance of hazard land encouraged?	no
7. Do hazard land occupants bear most of the costs?	no--but may loss development rights
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	yes--various regulations specified
9. Is the policy sensitive to the concerns of affected individuals?	variable--regulation not acceptable to some owners
10. Is there provision for public input or appeal of decisions?	yes
11. Is the policy crisis response or ad hoc?	no
12. Are there jurisdictional or administrative problems in applying the policy?	yes--limits on regulation of private property
13. Is the policy efficacious?	yes
14. Are there guidelines to ensure efficacy?	yes--various regulations specified
15. Is the policy based on adequate information and techniques?	yes--engineering and environmental studies
16. Is there provision for hindsight evaluation of the policy?	no

Protection and Management Act of 1970 provides for the regulation of high risk erosion, flood risk and environmental areas. The Act requires the Michigan Department of Natural Resources to make studies of areas of high erosion risk, flood risk and fish and wildlife value. These studies must develop guidelines for the regulation of areas designated under the above three categories. The Shorelands program provides for the adoption of zoning and other regulations for the use of these designated areas. After July 1, 1975, the Department is authorized to adopt and enforce regulations where local governments fail to do so.(88)

The shorelands to be zoned or regulated under the program include all land along the Great Lakes in Michigan situated within 1,000 feet landward of the ordinary high water mark, land between the ordinary high water mark and the water's edge and those lands, irrespective of the 1,000 foot boundary, which are affected by levels of the Great Lakes.

In response to the Shorelands Act, the Department of Natural Resources prepared a plan for Michigan's shorelands, outlining in preliminary terms high risk erosion and fish and wildlife areas and suggested guidelines for their protection and management.(89) A series of eight public hearings were held on this plan.

Prior to the passage of the Shorelands Act, the State of Michigan had no direct regulatory power over shorelands

above the ordinary high water mark. The Department of Natural Resources recognized that most shorelands were in private ownership, and that regulation of private property is constrained by constitutional and statutory limits.(90) They realized it was essential that regulations developed under the Shorelands program be based on a sound technical foundation.(91)

For high risk erosion areas designated by the Department, shoreland use regulations have been developed, including a 30 year structural set-back requirement for new buildings. The 30 year set-back is based on the assumption that most mortgages are now for a 30 year period.(92) No high risk erosion areas have been designated to date by the Department on Lake Erie, although the Department is directed to consider additional areas suggested by local governments, citizen groups, and others.(93) In this regard, the Monroe County Planning Commission has identified several high risk erosion areas along Lake Erie which may be designated.

For environmental areas designated by the Department, regulations have been developed restricting, among other things, filling or other land or soil alteration, alteration of natural drainage, removal of vegetation and placement of structures.(94) Two environmental areas, at Point Mouillee and Erie Marsh, were designated by the Department, involving a total of 34.3 miles of shoreline of which 10 miles are in private ownership. The Monroe County Planning Commission has designated an additional area near the City of Monroe.(95)

The Shorelands Act was amended in 1974 to include flood risk areas, and authorized an engineering study to determine flood risk areas and regulations to prevent flood damage. Suggested regulations include the prohibiting of creation of new building sites on land subject to 100 year flood elevations, the flood proofing of roads and utilities, the prohibition of on-site soil adsorption sewage disposal systems, the elevation of building above the 100 year flood line and prohibition of encroachments into floodways.(96)

The Shorelands program provides extensive procedures by which local governments and property owners can appeal area designations by the Department of Natural Resources. The Department must notify any local government and affected property owners of high risk erosion, flood risk or environmental area designations. Any property owner or local government contesting a designation can require a public hearing under a hearing officer appointed by the Department.(97) After the hearing, the officer submits a proposal for decision to the Natural Resources Commission which also holds a hearing on the matter and makes a ruling. This ruling can be appealed through the courts. These procedures are attempts to ensure that the police power over regulation of private property is not abused.

Zoning ordinances prepared by local governments respecting high risk erosion, flood risk or environmental areas must be approved by the Department of Natural Resources. Disapprovals can be appealed at a public

hearing. If a local government fails to adopt or enforce approved zoning ordinances or regulations for designated areas, the Department requires that any new shoreland use within designated areas must have a Department permit. Anyone refused a permit can require a public hearing on the matter.

The Shorelands Act is significant in that it extends State regulatory power to private land above the ordinary high water mark. Land lakeward of the ordinary high water mark has been under State regulation for some time. The Submerged Lands Act of 1955 defined the ordinary high water mark for Lake Erie at a fixed elevation for administative purposes. This Shorelands Act extends State regulatory control to shoreland landward of this fixed elevation. However, State regulation of high risk erosion and environmental areas, unlike flood risk areas, relates only to undeveloped, unplatted shorelands.(98) High risk erosion and environmental area designations would not apply to already subdivided lots on which buildings had not yet been erected. While the program undoubtedly has great significance to other shorelands in Michigan, most of the Lake Erie shoreline, with the exception of State owned parks and game reserves, is extensivley developed in permanent and seasonal residential uses. If, however, additional environmental areas are designated, the remaining wetland areas currently undeveloped can be effectively preserved under this program. The initiative for recommending such

designations will likely come from the County Planning Commission or citizens groups rather than local governments.

Over the years, many government reports and investigations have stressed the importance of land use regulation as an appropriate adjustment to flood and erosion hazards on the Erie shoreline. The Select Committee of the Ontario Legislature investigating Great Lakes levels emphasized zoning in its 1953 report, as did the 1973 report of the International Great Lakes Levels Board, after its nine year study of lake regulation. The recent report of the Canada-Ontario Great Lakes Shore Damage Survey makes a similar recommendation. It has only been recently, however, that governments actually have made arrangements to implement some measure of land use regulation for flood and erosion hazard areas. Activities under the National Flood Insurance program, Michigan Shorelands Management program and the federal Coastal Zone Management Act are examples on the south Erie shore. Here, traditional lack of state influence over land use regulation has been an inhibiting factor. Unfortunately, the currently highly developed nature of the south shore limits the potential value of regulation somewhat.

On the north Erie shore, the Province of Ontario has exercised more influence on local planning matters. However, while the Province has policies on hazard lands, particularly river valleys, a shorelands policy does not exist. Official plan hazard policies, intensification of

Conservation Authority activities in shoreline areas and the Haldimand-Norfolk lakeshore policy illustrate an increasing local or regional role in hazard land regulation on the north Erie shore.

It is also possible for governments to modify the loss potential by delineating and publicizing the degree of risk associated with shoreland development. In this regard, the $700,000 Canada-Ontario Great Lakes Shore Damage Survey provides a base of data on shore damages during the November 1972 to November 1973 period, shore property values, land use and ownership, shoreline physiography and recession and accession rates. This information can form a base for shoreline management and planning.(99) The Shore Damage Survey includes recommendations for an intensive public awareness effort regarding hazards.

The U.S. Army Corps of Engineers has also been active in delineating hazard lands on the Erie shoreline. Recently, the Corps has delineated 100 year flood elevations for the Great Lakes.(100) This information will be used by the Federal Insurance Administration in its National Flood Insurance program. The Corps is currently working on a comprehensive study of flood damages during the recent high water period on the Great Lakes which will be completed in 1979.(101)

Efforts to educate shore property owners and others about the nature and degree of risk associated with flood and erosion hazards on the Erie shoreline may meet with only

limited success. An examination of transcripts of the public hearings held by the International Joint Commission on its lake level regulation report suggests that many shore property owners do not understand the nature of flood and erosion hazards. Those who presented briefs at the hearings are undoubtedly among the most interested and concerned shore residents. Presumably they read the lake levels report and other information on the flood and erosion hazard problem. Yet these witnesses repeatedly indicated a failure to understand the causes of lake level fluctuations on Lake Erie. They were convinced that these fluctuations were not natural occurrences, and that governments were to blame for the flood and erosion problem on Lake Erie.(102) It may be that many shore residents would not be receptive to information on the nature and degree of risk associated with their properties.

Hazard Loss Redistribution Policy

As well as attempting to reduce hazard losses, governments can pursue a strategy of redistributing hazard losses, that is, absorbing a portion of private costs incurred due to flood and erosion hazards. Adjustments which seek to redistribute hazard losses are public disaster relief, subsidized insurance and income and property tax write-offs. These measures do not affect the hazard itself

in any way; rather, they attempt to ease the burden of hazard damages on individuals.

There are a number of government programs that redistribute hazard losses on the Erie shoreline, including Post Disaster Assistance in Ontario and the Small Business Administration, Farmers Home Administration, Federal Disaster Assistance Administration and National Flood Insurance programs in the United States. As well, most jurisdictions permit property tax assessment reductions and corporate income tax deductions for flood and erosion damages. The U.S. Internal Revenue Service allows similar deductions from personal taxable income. Two major hazard loss redistribution programs, the National Flood Insurance program and Small Business Administration loan program, are evaluated in some detail.

An evaluation of the National Flood Insurance program is summarized on Table 26. This program, administered by the Federal Insurance Administration(F.I.A.) of the U.S. Department of Housing and Urban Development, reduces the financial burden of flooding and storm induced erosion on individuals as well as future hazard losses by requiring municipalities to regulate development in hazard areas.

The National Flood Insurance program enables property owners in communities with Federal Insurance Administration identified flood or flood related erosion hazards to acquire insurance at affordable rates. To be eligible, a community must apply minimum F.I.A. land use regulations which are

TABLE 26

NATIONAL FLOOD INSURANCE PROGRAM (REDISTRIBUTE HAZARD LOSSES)

Evaluation Criteria	
1. Are there impacts on the physical environment?	no
2. Are there impacts on the biological environment?	no
3. Are there impacts on aesthetics and recreation?	no
4. Is an environmental impact analysis required or other environmental guidelines specified?	yes--municipalities must regulate land use
5. Are hazard damages reduced?	no--only in long term through land use regulations
6. Is continued occupance of hazard land encouraged?	yes--but not in long term
7. Do hazard land occupants bear most of the costs?	no--insurance subsidized 90% by federal government
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	yes--damaged property can be acquired
9. Is the policy sensitive to the concerns of affected individuals?	yes--but some developers oppose program
10. Is there provision for public input or appeal of decisions?	yes
11. Is the policy crisis response or ad hoc?	no
12. Are there jurisdictional or administrative programs in applying the policy?	yes--determining flood related erosion
13. Is the policy efficacious?	unknown--depends on municipal land use regulation
14. Are there guidelines to ensure efficacy?	yes--municipalities can be expelled from program
15. Is the policy based on adequate information and techniques?	yes--detailed hazard mapping
16. Is there provision for hindsight evaluation of the policy?	limited--annual report to President and Congress

designed to discourage future unprotected development in flood or erosion hazard areas. There are two programs under the National Flood Insurance program.(103) Under an emergency program, up to $35,000 insurance on single family dwellings and $10,000 on contents is available at subsidized rates regardless of risk. Once a detailed flood insurance study has been completed by the F.I.A., an additional $35,000 insurance on homes and $10,000 on contents is available to residents at acturial or nonsubsidized rates. For any new construction or substantial improvements in identified flood hazard areas, however, only insurance coverage up to $70,000 on homes and $20,000 on contents is available at acturial rates. Rates reflect the degree of risk. Properly flood proofed buildings can be insured at considerably less than improperly constructed buildings. Insurance under both the emergency and regular programs is available for multifamily and nonresidential buildings as well.

To be eligible for flood insurance under the above programs, a community must enact minimum F.I.A. land use regulations. If a community with an F.I.A. identified special flood hazard fails to enter the program by July 1, 1975, or within one year of identification, no federal or federally-related financial assistance can be provided for construction or acquisition of buildings within the flood hazard area. This includes mortgage loans from federal agencies or federally regulated conventional lenders.

The National Flood Insurance program has been criticized on the basis of its high cost and burden on American taxpayers. In the past, flood insurance has generally not been available because the private insurance industry views flooding as an uninsurable risk. Only homeowners in highly hazardous areas are interested in coverage. The actuarial premium required would be prohibitive. Under the National Flood Insurance program, it has been necessary to subsidize premiums by about 90%.(104) Thus most of the costs of the program are borne by the taxpaying public. While this may be a valid criticism of the program, it should be noted that disaster relief and other forms of assistance related to flooding are also burdensome on the general public. The National Flood Insurance program is intended to eventually replace disaster relief.(105) This has already happened to some extent along Lake Erie. While in excess of $12,205,000 in claims have been paid to policy holders along the Erie shoreline during the 1972-1975 high water period, the amount of federal assistance granted in Small Business Administration and Farmers Home Administration disaster loans and grants has dropped off considerably. Extensive disaster relief assistance was granted for the fall 1972 and spring 1973 floods, but very little assistance was necessary for later floods because most shoreline residents were covered under the National Flood Insurance program.

While it must be acknowledged that the National Flood Insurance program is an expensive relief measure, it has an important advantage over disaster relief in that it is aimed at reducing future flood losses by requiring communities to adopt land use regulations. As well, the program offers an opportunity for hazard land occupants to contribute through their premiums to their own protection and thereby gain a better understanding of the real costs of their continued occupance of hazard lands. In this regard, it could be argued that the subsidized premiums could be raised to better reflect the full costs involved in hazard land occupance and to reduce the burden on the general taxpayer. Subsidized rates are currently $0.25 and $0.35 per $100 respectively for building and contents coverage. A homeowner can insurance his building and contents for $35,000 and $10,000 respectively for an annual total premium of $122.50.(106)

The most important feature of the National Flood Insurance program is its attempt to reduce future damages by requiring communities to adopt land use regulations. To qualify for the emergency program, a municipality must require and review building permits for new construction and substantial improvements. The review must ensure that building sites are reasonably free from flooding.(107) For flood prone areas, the municipality must require the proper anchoring of structures, use of damage resistant construction materials and methods, adequate drainage of new

subdivisions and flood proofing of new or replacement utility systems.(108). For the regular program, municipalities must adopt additional regulations to require all new construction or substantial improvement be located at or above the 100 year flood elevation. Communities can be expelled from the program for failure to enforce minimum F.I.A. regulations. However, there is no provision in the legislation for monitoring communities for compliance with the requirements. To a certain extent, success of the program will depend on the good faith of local governments.(109) However, the F.I.A. is considering financial support to states to permit some monitoring of local government enforcement of regulations.(110) The question of monitoring will likely remain a weak area in the program.

During hearings on the National Flood Insurance program, there was some criticism of the technical basis of the program, specifically use of the 100 year flood as the basis for land use regulations.(111) Some recommended a lesser standard, while others suggested that 100 year elevations be determined solely on the basis of historical data. However, the F.I.A. decided on a 100 year standard based on both historical and hydrological data, arguing that it was a reasonable compromise between minor floods and the maximum probable flood.(112) It was also pointed out that the 100 year flood had already been accepted by other federal agencies and a number of states. Also concerning

the technical basis of the program, the Flood Disaster Protection Act of 1973 expanded the definition of flood to include flood related erosion along shorelines. It is this definition which makes most areas along the Erie shoreline eligible for flood insurance. Shoreline erosion must be caused by "waves or currents of water exceeding anticipated cyclical levels".(113) The flood insurance companies determine whether any particular case of erosion is a result of unusual water levels, that is, flood related. Normal or gradual erosion of shorelines is not included in the program. The F.I.A. is currently drafting land use regulations for use in erosion prone areas.

The National Flood Insurance program provides procedures for appeal of decisions. For example, both individuals and municipalities can appeal their designation by the F.I.A. as flood hazard areas. The appeals, however, must only be based on technical grounds. Similarly, individuals can appeal decisions by the insurance companies as to their eligibility for claims resulting from flood related erosion.

A final very significant aspect of the National Flood Insurance program concerns a provision by which the F.I.A. can purchase property located in any flood risk area, covered by the insurance program, and damaged substantially beyond repair.(114) Property purchased under this provision can be subsequently sold, leased or donated to any state or local agency agreeing to use the property consistent with

sound land management. This provision may prove useful in helping to ensure an efficient adjustment to hazard.

In Ontario, the provincial Flood Damage Working Group studied the National Flood Insurance program to determine if a flood insurance scheme might be feasible for the Great Lakes shoreline.(115) The Group noted the high cost of the U.S. program and the fact that individuals along the Great Lakes would only be interested in purchasing insurance during periods of high lake levels, when risks were greatest. They also noted that in the U.S., policy holders along the Great Lakes shoreline are an insignificant portion of total policy holders, most of whom would be interested in continuous coverage. The Group concluded that flood insurance would not be feasible for the Ontario Great Lakes shoreline.(116) Flood insurance, however, might be more feasible on a Canada-wide basis, where a majority of riverine policy holders would be interested in continuous coverage, thereby reducing premiums somewhat. In considering the feasibility of an insurance scheme in Canada, the public costs of disaster relief programs must be considered, as insurance should replace disaster relief. In Ontario, the costs of the Post Disaster Assistance program have not been excessive, due in part to the control Cabinet has over whether or not any particular disaster declaration is made. Federally, the costs of disaster relief have been considerable.(117) It must also be remembered that a major rationale for the U.S. insurance program is to encourage

local government adoption of land use regulations. In Ontario, efforts are already underway to establish effective hazard policies within municipal Official plans. And federally, the recent Environment Canada policy of denying federal disaster relief for new construction in identified flood risk areas may result in reduced losses at considerably less cost than the U.S. flood insurance program.

An evaluation of Small Business Administration Physical Disaster Loan program is summarized on Table 27. This program provides loans for the restoration of homes and businesses, to predisaster condition, damaged or destroyed by a physical disaster, such as flooding or storm induced erosion. The Small Business Administration(S.B.A.) of the U.S. Department of Commerce, which was established in 1953, developed a disaster loan program to aid businesses and homeowners affected by disasters. This program became the primary vehicle for administration of federal disaster aid for the rehabilitation of private property.

To be eligible for disaster loans, an area must be declared a disaster area by the administrator of the S.B.A. or by the President. Normally, local or state officials would request a declaration following a disaster and the S.B.A. would undertake a damage survey to determine the extent and magnitude of damage before making a declaration.

Under the terms of the program, a homeowner can borrow up to $50,000 to restore a residence, $10,000 to restore

TABLE 27

PHYSICAL DISASTER LOAN PROGRAM (REDISTRIBUTE HAZARD LOSSES)

Evaluation Criteria	
1. Are there impacts on the physical environment?	no
2. Are there impacts on the biological environment?	no
3. Are there impacts on aesthetics and recreation?	no
4. Is an environmental impact analysis required or other environmental guidelines specified?	no
5. Are hazard damages reduced?	no
6. Is continued occupance of hazard land encouraged?	yes
7. Do hazard land occupants bear most of the costs?	no
8. Is a benefit-cost analysis required or other efficiency and equity guidelines specified?	limited--some provision for relocation after disaster
9. Is the policy sensitive to the concerns of affected individuals?	yes--acceptable to shore property owners
10. Is there provision for public input or appeal of decisions?	yes--refused loan applications can be reconsidered
11. Is the policy crisis response or ad hoc?	yes--crisis response application of existing policy
12. Are there jurisdictional or administrative problems in applying the policy?	no
13. Is the policy efficacious?	yes
14. Are there guidelines to ensure efficacy?	yes--eligibility rules
15. Is the policy based on adequate information and techniques?	yes--based on damage survey
16. Is there provision for hindsight evaluation of the policy?	no

residential contents, or $55,000 for both purposes.(118) Businesses are eligible for a maximum $500,000 loan. Normal repayment period is 30 years. Most property owners, including cottagers, residential tenants, businesses of any size, religious, charitable or nonprofit organizations are eligible for S.B.A. disaster loans.(119) Farmers and other engaged in agriculture are not eligible for the S.B.A. program but are eligible for similar loans from the Farmers Home Administration of the Department of Agriculture. Loans may not be used to repair or replace extraordinarily expensive luxury items or recreational items such as boats or travel trailers. A loan can not exceed the actual loss suffered by the disaster victim after deducting any assistance from insurance, the Red Cross, or other government relief.

Until April 20, 1973, the S.B.A. program provided for the forgiveness of up to $5,000 of each loan, with the remainder of the loan repayable at 1% interest per annum.(120) After this date, the forgiveness feature was dropped and the interest rate raised to 5%.

During the 1972-1975 high water period on Lake Erie, several S.B.A. disaster declarations were issued which provided loans and grants to property owners along the south Erie shore totalling $16,608,472.(121) An estimated 85%, or $14,117,200, was forgiven. This represents a sizeable public subsidy for flood and erosion damages on the south Erie shore.

As with other forms of disaster relief, the S.B.A. loan program tends to promote continued occupance of hazard lands by facilitating the rehabilitation of property to predisaster condition. If a disaster victim voluntarily decides to relocate his building following a disaster, S.B.A. assistance will only cover the damage incurred and not additional costs due to relocation.(122) The inefficiency in disaster relief programs such as the S.B.A. physical disaster loan program is demonstrated dramatically by the Estral Beach, Michigan, example. Many families in this Erie shoreline village who received S.B.A. loans and grants following the November 1972 flood to effect repairs, received S.B.A. funds again following the March-April 1973 floods to repair their earlier repairs, only to have their repairs destroyed again in the June 1973 flood.(123) This, and similar cases, suggests that longer term efficiency might very well be enhanced by subsidies to encourage relocation or flood proofing. Certainly, in some cases, the additional public expense initially to encourage relocation or or loss potential modifications would yield long term benefits in reduced reliance on disaster assistance.

To some extent, S.B.A. loan program guidelines do enhance the efficiency of this form of disaster assistance. For example, if a disaster victim cannot obtain a building permit to restore his property at the disaster site, that is, if he is forced to relocate, the additional costs of relocation may be eligible for S.B.A. assistance.(124)

S.B.A. loans have apparently been used for relocation in Ashtabula County, Ohio.(125) A recent guideline requires that S.B.A. loans to restore property within a special flood hazard area must be covered by federal flood insurance.(126) This reduces further dependence on S.B.A. loans, and efficiencies possible under the National Flood Insurance program, such as purchase of damaged property, apply. As well, revisions to the S.B.A. loan program in 1973 removing the forgiveness features and increasing interest rates forces the disaster victim to realize the full costs of hazard land occupance. This will no doubt encourage further acceptance of the National Flood Insurance program as a substitute for disaster relief. Reduced dependence on the S.B.A. program following the June 1973 and April 1974 Lake Erie floods suggests that many shoreline property owners had purchased flood insurance.

Do Nothing Policy

A final broad strategy practiced by all levels of governments on occasion is to do nothing. This involves bearing the losses to public property and letting individuals bear the losses on private property or undertake measures to reduce losses to their property. Thus, when a government decides not to invoke a disaster declaration, for example, it effectively is doing nothing and letting individuals realize the full costs of hazard land occupance.

Some researchers have suggested that this strategy can sometimes be the most efficient in terms of least social costs. Burton, Kates and Snead(1969), for example, suggest that the first step towards a comprehensive damage-reduction program is to make loss bearing respectable. They argue that "loss bearing is and will continue to be a minimum cost solution for the use of shore in many areas".(127) They further suggest that individuals should plan for the loss by budgeting a reserve fund so as to spread the effect of a disaster over time. Visvader and Burton(1974) claim that natural hazards are of much less significance in Canada than the U.S. due to the distribution of hazards over the North American continent and the lower population in Canada. This fact, combined with the less central distribution of power in Canada, has generally discouraged a large scale federal intervention in hazards, as has occurred in the United States.(128) Certainly, this has been to the benefit of the majority of Canadian taxpayers. It is probable, then, that loss bearing has been and continues to be more prevalent in Canada. The lack of widespread application of disaster relief on the north Erie shoreline supports this contention.

While government agencies, in particular circumstances, have elected to do nothing and leave the burden of hazard adjustment with individuals, a totally 'do nothing' policy is not possible. First, many regulatory activities and programs are firmly entrenched in legislation, the Corps of Engineers permit program for example. While programs such

as the S.B.A. loan program, the National Flood Insurance program and the Ontario Shoreline Property Assistance program are basically responses to crises, they are not ad hoc. Legislative amendments could, of course, terminate these and other programs. Some means of reasonable disaster assistance, however, is widely accepted and likely to continue. Moreover, the removal of regulations over land use, construction of shore protection works and other activities would exacerbate shoreline problems and would be very acceptable.

A reasonable government policy, of course, lies somewhere between total government intervention and a total 'do nothing' policy. Governments should work towards a long term least social cost solution to shoreline hazard problems. This issue will be addressed in further depth in Chapter VI.

Implications of Erie Shoreline Hazard Policies

Table 28 summarizes implications of various Lake Erie flood and erosion hazard policies. This Table reveals that although most policies aimed at modifying the hazard cause and modifying the hazard are likely to reduce flood and erosion damages to some extent and are politically acceptable to shoreline property owners, they are likely to have detrimental impacts on the environment and encourage continued occupance of hazard land. Policies that seek to

TABLE 28

IMPLICATIONS OF LAKE ERIE SHORELINE HAZARD POLICY 1972-1975

Policy	adverse environmental impact?	hazard damages are reduced?	continued occupance encouraged?	acceptable to hazard land occupants?	cost sharing?
Reduce Hazard Losses					
Modify the Hazard Cause					
shore protection permits (U.S. Corps of Engineers)	variable	variable	variable	variable	
Modify the Hazard					
A.R.D.A. dyking (Ontario Agriculture)	yes	yes	yes	variable	45% federal 45% provincial
shoreline protection (Ontario Treasury)	variable	variable	yes	yes	loans
emergency assistance (Ontario Treasury)	variable	yes	yes	yes	80% provincial
Operation Foresight (U.S. Corps of Engineers)	yes	yes	yes	variable	100% federal
shore erosion contributions (Canada Public Works)	variable	variable	yes	yes	35% federal
beach erosion control (U.S. Corps of Engineers)	yes	limited	yes	variable	70% federal 30% state
Modify the Loss Potential					
flood forecasting-warning (Canada Environment)	no	limited	yes	yes	
shoreland management (Michigan Natural Resources)	no	yes	no	no	62% federal 38% state
Redistribute Hazard Losses					
flood insurance (U.S. Housing)	no	no	yes	yes	90% federal
disaster relief (U.S. Commerce)	no	no	yes	yes	85% federal
Do Nothing					
bear the losses	no	no	no	no	

modify the loss potential also reduce hazard damages, but are not detrimental to the environment and do not encourage continued occupance of hazard land. However, these policies are generally not acceptable to shoreline property owners. Policies aimed at redistributing hazard losses do not affect the environment or reduce hazard damages, but do encourage continued occupance of hazard land and are acceptable to shoreline property owners. A do nothing policy has no effect on the environment or hazard damages and neither encourages nor discourages continued hazard land occupance. However, a do nothing policy is not acceptable to all hazard land occupants. An important observation that emerges from this consideration of implications is that policies which are good for the environment and reduce damages are not generally acceptable to shoreline property owners. This reality of shoreline hazard politics is a major obstacle to more socially least cost solutions to flooding and erosion problems on Lake Erie and elsewhere.

Several issues implicit in Table 28 should be considered in greater detail. These concern environmental impacts of various policies and the effect of cost sharing arrangements.

Environmental Impacts

Most of the theoretical adjustments to Lake Erie flood and erosion hazards illustrated in Table 8 that aim to

modify the hazard cause and modify the hazard are likely to exert detrimental impacts on the environment. This is particularly true of lake level regulation and various shore protection works.(129) On both the north and south Erie shores, government arrangements exist for the assessment of environmental impacts. It is instructive to assess the application of these arrangements to policies undertaken or considered during the 1972-1975 high water period.

In the United States, various federal or federally financed projects are subject to the National Environmental Policy Act of 1969. This Act requires the project proponent to prepare an environmental impact statement for submission to the Council on Environmental Quality. The statements are scrutinized by the Council and the Environmental Protection Agency for completeness with respect to the intent of the Act. The final decision on the project, however, rests with the proponent. The National Environmental Policy Act affected very few flood and erosion hazard policies on the south Erie shore during the 1972-1975 period. The extensive Corps of Engineers Operation Foresight program, which involved the construction of over 40 miles of temporary shore protection on Lake Erie, as an emergency measure, was not subject to environmental assessment.(130) Cooperative beach erosion control projects and permanent lake flooding projects are subject to environmental review. A permanent lake flooding project was considered for Toledo during the 1972-1975 period, but Operation Foresight dykes

were constructed instead. Beach erosion control projects undertaken in Ashtabula County, Ohio, and at Presque Isle, Pennsylvania, were assessed for environmental impacts. Emergency protection of existing federal structures at Presque Isle, also undertaken during this period, was not subject to environmental review. A proposal for a partial breakwater as a 'permanent' solution to Presque Isle's erosion problem was subject to National Environmental Policy Act provisions and a draft environmental impact statement was prepared by the Corps of Engineers.(131) The impact statement identified a serious threat to ecological processes on Presques Isle, if a proposed partial breakwater is constructed. Permits for activities in navigable waters are also subject to environmental assessment, at the discretion of the Corps of Engineers. Apparently, no permits for shore protection along the south Erie shore issued during the 1972-1975 high water period were assessed for environmental impacts.(132)

All other federal, state, municipal and private actions on the flood and erosion problems on the south Erie shoreline were not subjected to the provisions of the National Environmental Policy Act. This includes many miles of shore protection constructed by individuals.

On the north Erie shore, the federal government operationalized its Environmental Assessment and Review Process(E.A.R.P.) early in 1974. Federal, federally financed and federal regulated activities are

reviewed by Environment Canada for possible environmental effects. This includes permits for construction in navigable waters issued by the Ministry of Transport under the Navigable Waters Protection Act. However, applications for exemptions from permit which apply to all but major works, are not screened by Environment Canada.(133)

Environment Canada did screen the Navigable Waters Protection Act permit application for the Port Burwell breakwater constructed under the Canada Department of Public Works shore erosion contributions program.. Environment Canada staff had no objections to this shore protection as they felt effects would not be significant.(134)

The A.R.D.A. Southwestern Ontario dyking projects in Harwich, Mersea and Pelee Townships were ongoing when Environment Canada's E.A.R.P. was initiated, and were exempted from environmental scrutiny.(135)

The Stelco dock and unloading facility at Nanticoke also required a Navigable Waters Protection Act permit. Environment Canada, along with the Ontario Ministries of Environment and Natural Resources, recommended a 900 foot bridged section in the littoral zone to allow for movement of fish and sediment in the nearshore zone. This recommendation was accepted by Stelco in 1974.(136) Environment Canada is receiving periodic updates on accretion and erosion in the area.

While the Port Burwell breakwater and Stelco unloading facility received some enviornmental review, most shore

protection by government agencies and individual property owners, including the massive A.R.D.A. shore protection, was not screened for possible adverse environmental impacts.

Overall, then, environmental impact assessment procedures had little effect on the Erie shoreline during the 1972-1975 period. The great bulk of shore protection works, both temporary and permanent, were constructed with little or no regard for the biophysical environment, aesthetics or recreation. Proposed lake level regulation schemes were assessed environmentally.

Environmental assessment of flood and erosion hazard policies, however, may improve, particularly on the north Erie shore. Federal assessment procedures, although informal in comparison to the National Environmental Policy Act, are now fully established and hopefully all future federal activities will be screened for potential adverse environmental impacts. Moreover, Ontario's Environmental Assessment Act of 1975 legislated procedures whereby provincial and municipal agencies must prepare environmental assessments for consideration and approval by the Minister of the Environment. These procedures apply to activities described by regulations as having potential impact on the environment. The Ontario Environmental Assessment Act represents a significant departure from the U.S. National Environmental Policy Act in that the Minister of Environment, not the proponent, exercises final control on whether a project will be undertaken. As well, the Act will

eventually apply to private activities as well as provincial and municipal actions.

Cost Sharing Arrangements

Various studies point to the impact of senior government cost sharing on the decisions of local interests to adopt particular types of hazard protection. Loughlin(1970) emphasized that differences in cost sharing policies within an agency and among agencies lead to social inefficiences and inequities.(137) In a study specifically relating to cost sharing for shoreline protection, Marshall(1974) showed that existing cost sharing policies of the Corps of Engineers for shore protection do not induce local interests to choose projects that are efficient from a national viewpoint.(138) Instead, local interests choose projects that, while least costly from a local viewpoint, are more costly and over built from a national perspective.

Cost sharing arrangements for various Lake Erie flood and erosion hazard policies are summarized on Table 29. This Table illustrates variety in the portion of total costs absorbed by senior governments for different hazard policies. It is not difficult to understand why local interests adopt certain adjustments rather than others. When senior government assistance is particularly high, local interests may push for more and larger projects than they might if they were paying a higher portion of the

TABLE 29

COST SHARING ARRANGEMENTS OF ERIE SHORELINE HAZARD POLICIES

Reduce Hazard Losses			
Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistriubte Hazard Losses
North Erie Shore			
Lake level regulation (100% federal)	A.R.D.A. dyking (45% federal-45% provincial)	Emergency measures (50% federal-40% provincial-10% municipal)	Post disaster assistance (50% provincial-50% local)
	Emergency assistance (80% provincial-20% municipal)	Land acquisition (50% provincial-50% local conservation authority)	
	Erosion contributions (up to 50% federal)	Hazard mapping (75% provincial-25% local conservation authority)	
	Drainage assistance (33-1/3% provincial)	Recreation land acquisition (up to 50% provincial)	
	Erosion control (50% provincial-50% local conservation authority)		
South Erie Shore			
Lake level regulation (100% federal)	Beach erosion control (70% federal-30% local)	Coastal zone management (80% federal-20% state)	Flood insurance (90% federal)
	Lake flooding (70% federal-30% local)	Recreation land acquisition (up to 50% federal-remainder local)	Disaster relief (85% federal)
	Operation Foresight (100% federal)		Disaster relief for public property (100% federal)

costs. It is likely, for example, in the case of the A.R.D.A. dyking in Harwich, Mersea and Pelee Townships that inefficient protection was built. Other forms of protection, for example, repairs and maintenance of existing dykes, may well have sufficed. Certainly, 90% senior government funding was a sizable inducement to undertaking large-scale protection. Cost sharing for the Port Burwell breakwater may also have lead to some inefficiency. The Village was able to take advantage of two programs of assistance, federal Public Works shore erosion contributions of up to 50% of total costs and 80% provincial Special Emergency Assistance funding. A small number of largely seasonal residences were protected at a cost to the municipality of $63,672 or 14% of total costs. Other alternatives, such as land acquisition or subsidized relocation may have been much more efficient in the long term and less costly than the $500,000 breakwater.

It has been suggested that cost sharing arrangements may affect the demand for particular adjustments.(139) That is, large senior government assistance may encourage local interests to adopt more of a particular adjustment. Clearly, during the 1972-1975 high water period, there was high demand for adjustments with a high percentage of senior government subsidy. There is evidence, for example, of higher demand for A.R.D.A. dyking than was satisfied by the program. Four additional Essex County municipalities wanted to participate in the A.R.D.A. program, and Mersea Township

had expressed an interest in additional projects, but funds were diverted to the costly Lake St. Clair dyking.(140)

It is important to note that while there is variability in cost sharing arrangements for Erie shoreline hazard adjustments, senior governments generally absorb at least 50% of the costs of programs that modify the hazard and redistribute hazard losses. Thus, a large part of the costs of these programs is borne by the wider taxpaying public.

The Costs of Government Shoreline Hazard Policies

It is possible to offer a tentative inventory of the costs of government policies for dealing with flood and erosion hazards on the Erie shoreline. Important issues here are the nature and magnitude of costs and the relation between damages incurred and costs expended.

Table 30 lists the costs of various senior government programs that sought to reduce or redistribute hazard losses on the Erie shoreline during the 1972-1975 period. It must be emphasized that the dollar figures shown are conservative estimates of the costs of government response to flooding and erosion on Lake Erie. For many agencies, it is difficult to separate costs applicable to Lake Erie shoreline hazards from their total operating budgets. For example, both federal governments provide flood forecasts and issue warnings, although it is difficult to separate costs of providing these services to Lake Erie shore

TABLE 30

NATURE AND DISTRIBUTION OF LAKE ERIE SHORELINE HAZARD POLICY COSTS 1972-1975

Agency	Modify the Hazard Cause	Modify the Hazard	Modify the Loss Potential	Redistribute the Loss	Total
North Erie Shore		$6,485,000 (95%)	$162,000 (2%)	$165,000 (3%)	$6,812,000 (100%)
Canada Environment		654,000	81,000		
Canada Regional Economic		1,350,000			
Canada Public Works		166,000			
Total Federal		2,170,000	81,000		2,251,000 (33%)
Ontario Natural Resources		221,000	81,000		
Ontario Agriculture		2,004,000			
Ontario Treasury		1,900,000		165,000	
Ontario Transportation		190,000			
Total Provincial		4,315,000	81,000	165,000	4,561,000 (67%)
South Erie Shore		15,284,000 (26%)	473,000 (1%)	42,602,000 (73%)	58,359,000 (100%)
U.S. Corps of Engineers		14,081,000			
U.S. Commerce			271,000	14,117,000	
U.S. Housing				16,003,000	
U.S. Internal Revenue				10,661,000	
U.S. Agriculture				1,485,000	
Total Federal		14,081,000	271,000	42,266,000	56,618,000 (97%)
Michigan Natural Resources		55,000	2,000		
Michigan National Guard		38,000			
Michigan Social Services				5,000	
Ohio Transportation		297,000			
Ohio Natural Resources			166,000		
Ohio Taxation /				331,000	
Pennsylvania Resources		788,000	26,000		
New York Conservation			8,000		
New York Transportation		25,000			
Total State		1,203,000	202,000	336,000	1,741,000 (3%)

property owners from total weather forecasting and warning costs. For costs that are reasonably identifiable with Lake Erie hazards, quantitative estimates are provided in Table 30. In other cases, the nature of costs are simply described with no attempt at measurement. It is believed, however, that the costs of structural measures to modify the hazard and the costs of redistributing losses are reasonably complete.

An examination of Table 30 reveals some striking differences between response to flood and erosion hazard on the north and south Erie shorelines. Most obvious, is the considerably larger financial commitment to the hazard problem on the south shore. This is due, in part, to the much larger magnitude of damages sustained during the 1972-1975 high water period. More significant, however, is the nature of financial commitment. Approximately 95% of the calculable government expenditures on the north Erie shore are for measures to modify the hazard, notably shore protection works. The A.R.D.A. dyking program alone accounts for about 57% of the total federal and provincial costs listed on Table 30. Conversely, the commitment to redistributing losses is very small, less than 3% of the total expenditures. Disaster relief arrangements for the north shore exclude cottagers, a predominant group of shore property owners.

On the south Erie shore, however, some 73% of total government expenditures are for redistributing losses, and

only 26% for modifying the hazard. Clearly, a number of disaster compensation programs applicable to the south shore are well established. These include the Small Business Administration and Farmers Home Administration disaster relief program, the Federal Disaster Assistance Administration program and the National Flood Insurance program. Moreover, these programs do not exclude cottagers, effectively raising the burden on the general taxpayers. Public assistance for protecting private property is not well established. Were this not the case, federal expenditures on modifying the hazard would have been considerably higher.

The measurable financial commitment to modifying the hazard cause and modifying the loss potential is insignificant in comparison to other costs. However, it must be noted that the costs of administering land use regulations and other loss potential modification policies have not been estimated. Some cost information is available on hazard mapping and coastal zone management.

Also significant are differences in the financial commitment of various levels of government on the north and south Erie shorelines. On the north Erie shore, the province is most committed to Erie hazard problems, with 67% of the total costs, while the federal government absorbed about 33% On the south Erie shore, the federal government dominates with about 97% of total measurable costs, compared with about 3% by the four states involved. This reflects a

well established federal commitment to natural hazards in the United States, particularly for disaster relief. While no municipal costs are estimated for the south shore, these are likely to be relatively insignificant as the Federal Disaster Assistance Administration absorbs some municipal costs.

Table 31 provides additional comparisons of government response to flood and erosion hazards on the Erie shoreline. Both hazard damages and government assistance per shoreline mile during the 1972-1975 high water period are considerably higher on the south shore. Damage amounts to $250,000 and $16,000 per mile respectively for the south and north shores. Government assistance amounts to $140,000 and $18,000 per mile respectively on the south and north shores. While these figures are crude estimates, it is probable that government assistance on the north Erie shore exceeded the actual value of flood and erosion damages sustained during the 1972-1975 period. This is largely due to the costly A.R.D.A. dyking program. Indeed, extluding the A.R.D.A. assistance, government assistance as a percentage of damages are roughly equal on the north and south shores, 51% and 56% respectively.

Per mile costs of mpdifying the hazard and redistributing hazard losses reveal some interesting comparisons. The per mile costs of modifying the hazard, primarily shore protection works, are $17,000 and $37,000 respectively for the north and south shores. However, per

TABLE 31

GOVERNMENT HAZARD ASSISTANCE IN RELATION TO LAKE ERIE SHORELINE HAZARD DAMAGES 1972-1975

Shoreline Area	Total Assistance	Total Damages	Total Response[1]	Subsidy to Individuals[2]	Relief to Individuals[3]
North Erie Shore	$6,812,000	$6,232,000	109%	79%	3%
(378.7 miles)	($18,000)	($16,000)			
Essex County	3,433,000	2,994,000	115	103	6
(75.6 miles)	(45,000)	(40,000)			
Kent County	1,849,000	1,054,000	175	168	
(72.3 miles)	(26,000)	(15,000)			
Elgin County	457,000	101,000	452	34	
(56.0 miles)	(8,000)	(2,000)			
Haldimand-Norfolk Region	931,000	1,588,888	59		
(138.7 miles)	(7,000)	(11,000)			
Niagara Region	142,000	496,000	29	4	
(36.1 miles)	(4,000)	(14,000)			
South Erie Shore	58,359,000	104,142,000	56	60	45
(416.8 miles)	(140,000)	(250,000)			
Michigan	22,936,000	43,113,000	53	61	46
(32.5 miles)	(706,000)	(1,327,000)			
Western Ohio	25,569,000	49,458,000	52	58	43
(157.3 miles)	(163,000)	(314,000)			
Eastern Ohio	6,190,000	7,851,000	79	82	56
(107.8 miles)	(57,000)	(73,000)			
Pennsylvania	2,517,000	2,260,000	111		
(48.3 miles)	(52,000)	(47,000)			
New York	1,147,000	1,460,000	79	90	81
(70.9 miles)	(16,000)	(21,000)			

Notes: 1. Total government assistance as a percent of total public and private property damages.
2. Government assistance to individuals as a percent of private property damages.
3. Government hazard relief assistance to individuals as a percent of private property damages.

mile costs of redistributing hazard losses are $400 and $102,000 respectively for the north and south shores. Again, this reflects the existence of well established federal disaster relief programs in the United States.

From information available, it is obvious that considerably more emphasis has been placed on redistributing hazard losses on the south Erie shore, and reducing hazard losses on the north shore by means of shore protection works. While the commitment to construction works on the north shore holds promise of some reduction in future hazard damages, both modifying the hazard and redistributing hazard losses promote continued and even further occupance—of hazard lands at the expensive of general taxpayer and the relative neglect of alternative adjustments, for example, policies aimed at modifying the loss potential.

Table 31 shows that total government assistance to private shore property owners as a percentage of total losses to those property owners on both the north and south Erie shores was substantial, 79% and 60% respectively. This includes all government assistance to private property owners, for construction of shore protection works and public relief. Public disaster assistance to private property owners as a percentage of total losses to those property owners on the north and south Erie shores was quite dissimilar, 3% and 45% respectively. Governments on both the north and south Erie shores are subsidizing property owners to a considerable extent. This raises an important

equity issue. Many property owners have voluntarily located along the Erie shoreline to derive recreational and other benefits from a coastal location. Moreover, many of these property owners are willing to continue to occupy hazardous shore areas in spite of damages suffered.(141) While a coastal location is necessary for some activities, industry, power generation and navigation, it is not essential for residential uses. Yet, the wider taxpaying public is paying a portion of the costs of these non-essential shore uses and apparently deriving relatively little benefit. It might even be argued that in areas such as the Niagara and Haldimand-Norfolk Regions, where cottaging is extensive along the Erie shoreline, the general public incurs an additional cost in reduced public recreational access to the shoreline.(142) A strong argument, therefore, can be made for requiring shore property owners to pay the costs of their hazardous locations in proportion to ratio of private to public benefits.(143) Thus, where the public derives little benefit from protecting a coastal land use, there should be little public subsidy. Conversely, where the public derive great benefit from protecting a coastal land use, regardless of whether that use is public or private, a case can be made for greater public subsidy.

Table 31 also provides a more detailed breakdown of damages and government assistance on the Erie shoreline by counties or groups of counties. This Table reveals a

general west to east decline in damages and government assistance, reflecting the greater hazard potential at the western end of the Lake. This Table also suggests that government assistance is not well distributed in relation to damages. Per mile assistance is considerably higher in Essex and Kent Counties, for example, due largely to the massive A.R.D.A. program. Similarly, in Elgin County, Port Burwell received heavy subsidies for shore protection from the Canada Department of Public Works and the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs. As well, government assistance per mile is higher than per mile damages in Erie County, Pennsylvania, due to the massive federal and state aid for erosion control at Presque Isle State Park.

A more detailed analysis for selected areas reveals even more dramatic disparities in assistance as a percentage of damages. For example, Pelee Township 739%, Norfolk and Delhi Townships, 54%. On the south Erie shore, with the exception of the Presque Isle area, there does not appear to be significant variations in relation to damages. This is due, in part, to the greater use of nondiscriminatory disaster relief programs, with a close relation between damages and aid granted. On the north Erie shore, however, the predominant form of assistance is aid for construction of protection works and this aid has been administered on a much more ad hoc basis. Thus, in municipalities such as Pelee, Harwich and Mersea Townships and the Village of Port

Burwell, relatively few individuals are benefitting from massive government assistance for shore protection works.

Conclusions

The evidence presented in this Chapter suggests the following conclusions about Lake Erie flood and erosion hazard policy:

First, policies that aim to modify the hazard cause and modify the hazard address the biophysical component of the natural hazard system. Thus, structural policies such as lake level regulation and shore protection works have important environmental implications. These policies are costly and are of highly variable effectiveness in reducing flood and erosion hazard losses. As well, they encourage continued and even further occupance of hazard lands. These factors combine to reduce the economic efficiency of these types of adjustments. Because of the recurring nature of Erie shoreline hazards, shore protection works require continual maintenance and reconstruction and are often not efficient in the long term. Moreover, cost sharing arrangements can encourage further inefficiency. These policies, however, are widely accepted by shore property owners and represent an expedient response for governments during times of crisis. They account for 95% and 26% of total measurable government hazard expenditures on the north and south Erie shores, respectively, during the 1972-1975

high water period, when some $6,485,000 and $15,284,000 were committed by governments on the north and south shores. Jurisdictional and other problems have rendered application of these policies inequitable. In the United States, for example, the government can subsidize flood protection on private land but not erosion protection. On the north Erie shore, only farmers in municipal drainage schemes received assistance under the A.R.D.A. Dyking program.

These structural policies require detailed knowledge of coastal processes, something which is seldom available. This accounts for inefficiency in some cases, where costly shore protection works fail. Coastal processes are highly variable and complex; erosion and accretion can occur within hundreds of feet along a shoreline. Structural measures to modify the hazard cause and modify the hazard seek to increase the interaction between human and biophysical processes that constitute the hazard, that is, to confront nature. The recurring nature of Great Lakes flood and erosion hazards, however, means that a continued, costly commitment is necessary with this structural approach to hazards.

Second, policies aimed at modifying the loss potential address the human component of the natural hazard system. These policies can be more efficient and effective than the foregoing in reducing hazard losses. They seek to reduce, rather than increase, the interaction between human and biophysical processes. For example, land use regulation

might exclude human occupance in highly hazardous areas. Or, a flood proofing policy might allow, in hazardous areas, development that is hazard tolerant in its design. By reducing the interaction between human and biophysical processes, these policies create an opportunity for greater efficiency in reducing future hazard losses.

Unfortunately, policies aimed at modifying the loss potential are not generally acceptable to shoreline occupants. Zoning and other regulations are viewed as infringements on private property rights. There has been little emphasis on modifying the loss potential on the Lake Erie shoreline, although interest in this approach is increasing.

Third, policies aimed at redistributing hazard losses do not address directly either the human or biophysical processes involved in natural hazards. These policies simply reduce the financial burden of individuals suffering hazard losses. Because these policies do not attempt to reduce hazard losses, they can be very inefficient as a response to recurring hazards, such as flooding and erosion on the Lake Erie shoreline. In Estral Beach, Michigan, for example, residents received disaster relief three times during a one year period to effect repairs to their earlier repairs. Hazard loss redistribution policies are very acceptable to hazard land occupants, and permit their continued existence in hazardous shoreline areas. Disaster relief has been stressed on the south Erie shore, where

government expenditures of $42,602,000 constituted 73% of total government hazard assistance during the 1972-1975 high water period. Disaster relief under established United States federal programs is reasonably equitable, with seasonal as well as permanent residents eligible for assistance. Disaster relief was not stressed as a response to flooding and erosion on the north Erie shore and the public subsidy for this type of adjustment was relatively insignificant.

Fourth, a do nothing policy is not acceptable to shore property owners, yet, this approach to hazards may be a socially least cost solution in some cases. Provincial disaster relief costs, for example, would have been considerably higher if the Ontario Cabinet had designated disaster areas in addition to Essex and Kent Counties. Thus, the burden on the Ontario taxpayer was reduced by the do nothing response to other requests for disaster relief during the 1972-1975 high water period.

Fifth, many problems concerning particular policies have been discussed in this Chapter. In general, policies lack flexibility. Disaster relief programs, for example, do not allow or encourage relocation or flood proofing. Many policies lack provision for land acquistion. These are important considerations, as subsidized relocation, flood proofing or public land acquisition offer opportunities for reducing almost certain future damages and increasing efficiency. The National Flood Insurance program has such a

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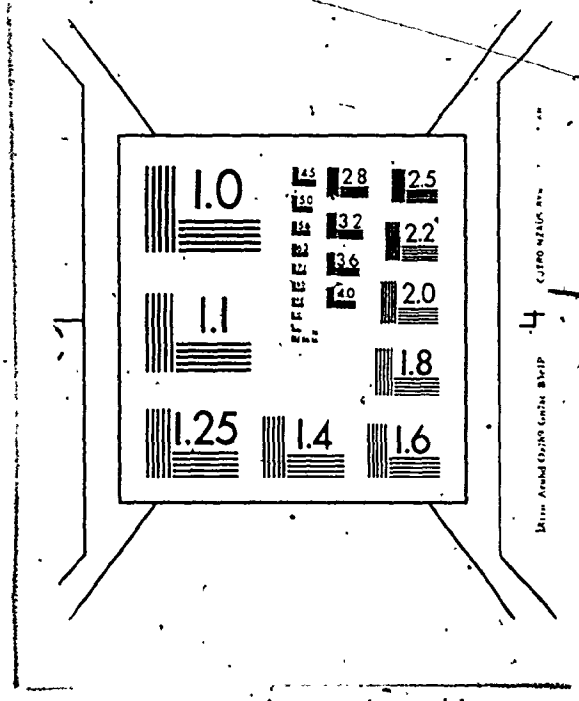

provision and other programs should as well. At the same time, some policies lack guidelines to ensure efficiency, equity and effectiveness. The 90% senior government A.R.D.A. assistance to municipalities was essentially a gift of funds with few guidelines attached to influence municipal use of the funds. For example, municipalities were not required to consider whether the benefits of their projects were greater than the costs.

And sixth, government response to the 1972-1975 high water crisis was costly. Public subsidy to private property owners was estimated to be $4,425,000 and $49,969,000 on the north and south Erie shores, respectively. This represents subsidies of 79% and 60% of total private property damages, respectively. Yet, in few cases does the general public appear to receive recreational or other benefits. Here, an approach that seeks to modify the loss potential offers advantages. Land use regulation reduces the burden on the general taxpayer. Public land acquisition can provide public recreational areas which, near urban centres, may be particularly valuable. Other public benefits from land use regulation, relocation or land acquisition include savings in the provision of sewer and water services for expensive to service linear shore development. Under the Great Lakes Water Quality Agreement, considerable funds are being expended to service shore areas along the Great Lakes.

Policies that attempt to reduce hazard losses by modifying the hazard, specifically shore protection, may be

justified for some shoreline areas where land use is particularly necessary or valuable and only after undertaking benefit-cost and environment impact studies. However, more emphasis should be placed on measures that modify the loss potential. Disaster relief, by itself, is generally an inefficient approach to recurring Lake Erie flood and erosion problems.

This suggests the need to investigate means of reducing losses and, ultimately, government hazard assistance.

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CHAPTER VI

HAZARD LOSS REDUCTION ON THE NORTH ERIE SHORE

In this Chapter, possible futures or scenarios are developed to illustrate the implications of several broad strategies for adjusting to flood and erosion hazards on the north Erie shore. Each scenario builds on the hazard adjustment experience on both the north and south Erie shores, as developed in earlier Chapters.

Three scenarios can be identified:

First, existing hazard policy is continued. That is, government flood and erosion hazard policy expressed during the 1972-1975 high water period continues in effect on the north Erie shore.

Second, existing hazard policy is modified. That is, relatively minor or incremental changes are made in government flood and erosion hazard policy as expressed on the north Erie shore during the 1972-1975 high water period.

And third, new hazard policy for dealing with north Erie shoreline flooding and erosion is introduced. This new

policy involves arrangements that might range from a hazards-specific agency to comprehensive coastal zone management.

It is first necessary to consider the implications of continuing with existing hazard policy.

Continuing Existing Hazard Policy on the North Erie Shore

It is possible to summarize the essential aspects of Lake Erie shoreline flood and erosion hazard policy expressed during the 1972-1975 and earlier periods. It is also possible to consider generally the implications of continuing existing hazard policy on the north Erie shore in terms of the evaluation criteria specificed in Chapter II.

On the north Erie shore, senior government hazard assistance has been aimed largely at the construction of shore protection works in selected areas, notably municipal agricultural drainage schemes and municipal roads. There has been only limited application of disaster relief and little emphasis on hazard zoning or acquisition of hazard land. As well, there has been very little application of economic, social or environmental criteria in decision-making. At best, there has been some consideration of engineering or technical issues.

The emphasis on shore protection along the north Erie shoreline has important environmental implications. Accelerated shore erosion in some areas has been attributed

to shore protection works in adjacent areas, such as along the east beach at Pelee. Shore protection may result in additional drainage of marsh lands. As well, structures along the shore inhibit recreational access and are viewed by some as visual blights on the shoreline. In the absence of appropriate environmental guidelines and enforcement of an environmentally sensitive shore protection permit program, structures will continue to threaten shore ecology and aesthetics.

Shore protection assistance and disaster relief programs encourage continued occupance of hazard lands. Shore protection works may offer some reduction in hazard damages, although repeated and increasingly costly commitments to protection may result. In constant 1973 dollars, for example, 1951-1952 structural adjustments to protect farmland in the Rondeau and Pelee areas totalled $1,016,000 compared with 1973-1974 costs of $3,089,000.(1)

As well as their increasing cost, the economic efficiency and equity of structures can be questioned. Great differences in per acre costs of farmland protection under several A.R.D.A. projects suggest that more efficient protection could have been provided at Rondeau. At Port Burwell, it appears that the cost of a federal-provincial-municipal breakwall exceeded the value of shore property protected. It has been estimated that protection costs exceed property values along 73% of the lower Great Lakes shoreline.(2) Shore protection can also be

questioned in terms of equity, that is, who benefits and who pays. In the case of the A.R.D.A. dyking program, for example, relatively few farmers benefited at considerable public expense. The issue of equity can also involve discrimination in terms of who does or does not benefit from protection programs.

Disaster relief programs can also be scrutinized on economic efficiency and equity grounds. In this respect, it is most significant that the south Erie shore experience suggests that any further extension of disaster relief programs on the north Erie shore, making cottagers eligible for example, will be very costly to Ontario and, possibly, Canadian taxapayers generally. The south shore experience shows the inefficiency of disaster relief programs that encourage property owners to rebuild in areas of recurring hazard. The federal government in the United States hopes to replace disaster relief programs with subsidized flood insurance that requires municipalities to regulate further hazard land encroachment.

The scenario of continuing with existing hazard policy on the north Erie shore, particularly the emphasis on shore protection, can also be examined in terms of political and administrative issues. Shore protection projects are often controversial, as both the north and south Erie shore experiences demonstrate. Cottagers in both the Rondeau and Pelee areas were aggravated by the A.R.D.A. dyking program and felt they had little opportunity to influence the

decisions that affected them. Of more fundamental significance, is the fact that political and administrative factors largely contribute to the emphasis on shore protection structures. There is no single agency that commands or coordinates a wide range of adjustments for dealing with the shoreline hazard problem. Typically, a great many agencies at the federal, provincial and municipal levels of government have been involved in shoreline hazards in a rather independent, ad hoc and crisis response manner. Senior levels of government are limited in the extent to which they can, or wish, to influence local land use and development decisions and have found it expedient to provide large subsidizes for shore protection during times of crisis.

Finally, this scenario of continuing with existing hazard policy can be considered on a technical basis. While engineering studies have been undertaken with major government shore protection projects, it can be questioned whether or not coastal processes are well enough understood in particular areas for structures to be effective. Technical adequacy can also apply to other adjustments, such as seiche and storm surge forecasting. A further technological-informational deficiency in existing north Erie shore hazard policy concerns the virtual lack of monitoring or hindsight evaluation of programs and projects with a view to improving the technical and other bases on which hazard decisions are made.

A major implication of continuing with existing hazard policy conerns the effects of continued encroachment of damage susceptible residential and commercial uses onto hazardous shore areas. In the absence of effective land use regulation, the currently private agricultural, recreational and undeveloped land on the north Erie shore will be converted to developed residential and commercial uses by 1996, assuming therateof conversion in these land uses experienced during the 1966 to 1973 period continues.(3) Furthermore, assuming that currently public land remains public, the shoreline is protected no more effectively than in 1973 and that the density, value and hazard susceptibility of development remains at 1973 levels, then potential single year shore property damages in excess of $7,690,000(in 1973 dollars) can be expected by 1996. This represents a 71% increase over 1973 damages. The implications of further north Erie shore development are shown on Table 32. Townships have been grouped into regions of similar hazard susceptibility and density of development, as reflected in 1973 damages per mile of developed shoreline.

This 71% increase in potential single year damages by 1996 seems realistic in light of an estimate by the Great Lakes Basin Commission(1975) that by 1996, damages could be 76% greater than 1973.(4) If, however, the currently undeveloped land on the north Erie shore were developed to the density, value and hazard susceptibility of the 1973

TABLE 32

IMPLICATIONS OF FURTHER NORTH ERIE SHORE DEVELOPMENT

Region	Developed Shoreline	Undeveloped Shoreline	1973 Shore Damage	1973 Damage per Developed Mile	Further Shore Damage
Essex County	32.1 miles	22.8 miles	$2,344,038	$73,023	$1,664,924
Kent County (west of Harwich Township)	14.7	14.3	167,651	11,405	163,092
Harwich Township	13.7	7.3	608,451	44,412	324,208
Elgin County and Kent County (east of Harwich Township)	17.5	48.0	103,631	5,922	284,256
Norfolk, Delhi, Nanticoke and Haldimand Townships	53.5	36.1	968,407	18,101	653,446
Haldimand-Norfolk Region (east of Haldimand Township) and Niagara Region	32.7	10.1	312,018	9,542	96,374
Total North Erie Shore	164.2	138.6	4,504,196		3,186,300

Source: Based on information in Canada-Ontario Great Lakes Shore Damage Survey, Technical Report; Canada-Ontario Great Lakes Shore Damage Survey, Coastal Zone Atlas.

average(damages of $27,431 per developed mile), then 1996 damages would be $8,306,000 or 84% greater than 1973. And, if development of currently undeveloped land occurs at a higher than currently average density, value or hazard susceptibility, much greater increases in future damages can be expected. The 71% increase estimated may well prove to be a conservative estimate of potential 1996 damages.

In summary, the scenario of continuing with existing hazard policy on the north Erie shore suggests that if a period of high water recurred in the 1990's, property damage could exceed the level incurred during the 1972-1975 period by at least 71%. This would largely result from a policy that attempts to modify the hazard rather than minimize the loss potential through measures such as relocation, flood proofing, public hazard land acquistion, and hazard land mapping and regulation. In a crisis atmosphere, we can expect that senior government agencies would respond to requests from property owners and muncipalities for shore protection, and that massive subsidies would benefit relatively few individuals in specific areas. Decisions to provide these shore protection subsidies would not be based broadly on environmental, economic or social guidelines and would further reinforce the long term commitment to periodic protection subsidies.

Modifying Existing Hazard Policy on the North Erie Shore

This second scenario envisages a number of changes in existing government policy for north Erie shore hazards that are suggested by the Erie shoreline hazard experience. These changes in programs would help to reduce the long term total hazard costs on the north Erie shore and are incremental, rather than revolutionary, in nature.

A first modification involves changes in several grant and loan programs providing assistance to property owners on the north Erie shore. These programs could be made more flexible to facilitate relocation and flood proofing. For example, the Post Disaster Assistance program could subsidize relocated or flood proofed rehabilitation of damaged buildings rather than rehabilitation to predisaster condition only. The south Erie shore experience clearly demonstrates the economic inefficiency of relief programs that simply provide assistance for property owners to rebuild in areas of recurring hazard. Programs aimed at assisting property owners to protect their properties could also be more flexible. For example, a much more efficient solution to erosion of cottage properties at Port Burwell might have been subsidized relocation, rather than construction of a $500,000 breakwall under the Canada Department of Public Works erosion contributions program. Similarly, loans under the Shoreline Property Assistance program could be used for relocation or flood proofing,

rather than exclusively for construction of shore protection works or rehabilitation of damaged buildings.

A second modification to existing hazard policy on the north Erie shore might be the application of economic, social and environmental considerations, in addition to engineering considerations, in the selection, planning and implementation of programs. Such a broader decision-making base might help avoid inefficient or environmentally adverse projects and encourage less grandoise structural projects or even alternatives to structural measures. Some consideration of economic benefits and costs and environmental consequences would seem a minimum effort. Particular attention should be given to impacts on littoral processes and wetlands. Several recent measures in Canada and Ontario should help to broaden the decision-making base.

Environment Canada's environmental assessment and review process was initiated during the 1972-1975 period, but was not operational in time to affect decision-making over large scale federal projects such as the A.R.D.A. dyking program.(5) However, this administrative arrangement potentially represents a mechanism whereby federal or federally related projects can be screened for adverse environmental impacts.

In Ontario, the Environmental Assessment Act was passed in 1975 and became operational, in part, in 1976. Eventually, environmentally significant projects of the Province, municipalities and private sector will be subject

to a formal environmental impact analysis procedure. Unlike the United States legislation, the Ontario Environmental Assessment Act authorizes the Minister of the Environment to approve or reject the project under assessment. However, a number of projects are currently exempted from the provisions of the Act, including land drainage projects of the Ministry of Agriculture and Food.(6) Land drainage has had a significant impact on shore ecology in areas such as Pelee and Rondeau.

While some progress has been made in the area of broadening the decision-making base by recognizing environmental implications, there is considerable opportunity for improvement. Decisions regarding coastal hazard adjustment on the north Erie shore should be based broadly on economic, social and environmental, as well as engineering or technical, information and debated openly in public meetings and hearings to provide ample opportunity for input by interested citizens and groups.

A third modification to existing north Erie shore hazard policy could be made in the area of enforcement of federal and provincial shore protection permits. While the Ministry of Natural Resources has issued a number of permits in Essex-Kent area, the existing permit procedures do not appear to be enforced elsewhere along the shoreline. As provincial permit procedures are based on the Public Lands Act and ownership of much of the Erie shore is confused, many private shore protection works have been built without

a provincial permit. The federal system is based on the need to protect navigable waters from obstructions that might interfere with navigation and generally only the more major docks and other structures have been subjected to the permit procedure. As a consequence of rather limited and variable enforcement enforcement of existing federal and provincial permit procedures, many poorly designed, constructed and inappropriately located shore protection works have been built. In some cases, these structures aggravate erosion problems or simply transfer the problems to adjacent property owners.

Federal permit applications are now screened under the E.A.R.P. process, but the provincial permit system seems to lack any explicit guidelines concerning environmental suitability. The imposition of a limit on the length to which groynes can extend into the Lake would reduce some of the problems associated with this form of protection. The Buffalo District of the U.S. Army Corps of Engineers, for example, does not permit groynes to extend beyond the three foot contour below the mean high water level. Furthermore, it would seem appropriate to impose an administrative boundary, similar to the 573.6 foot elevation used by the Corps of Engineers on Lake Erie, for enforcement of shore protection permits on the north Erie shore.

The enforcement of an environmentally sensitive shore protection permit program would help to reduce the

construction of ineffective and visually unaesthetic shore protection works.

A fourth modification to existing north Erie shore hazard policy suggested in this scenario concerns the regulation of development in hazardous shore areas. The south Erie shore experience has shown that encroachment into hazardous shoreline areas following the 1951-1952 high water period has been costly in terms of damages sustained during the 1972-1975 period. Any reduction in hazard susceptible development on the north Erie shore can be expected to reduce hazard losses. Obviously, if no further hazard susceptible development were permitted on the north Erie shore, the 71% increase in potential damages expected by the 1990's would not materialize. Any improvements in land use regulation will be reflected in reduced future hazard costs for both property owners the wider taxpaying public.

In this regard, the initiative of the Regional Municipality of Haldimand-Norfolk in developing a coastal land use policy is encouraging. Since implementation of this policy in April, 1976, the regional council has rejected approximately 50% of applications for development in the municipality's coastal zone.(7)

This scenario envisages a shift in emphasis from structural projects that seek to modify the hazard to those that attempt to reduce losses by modifying the loss potential. The desirability of such a shift in policy has been recognized recently. In the United States, the federal

Water Resources Development Act of 1974 requires that in any federal project involving flood protection, nonstructural alternatives must be given consideration. The Act provides that federal cost sharing for nonstructural alternatives be comparable to structural alternatives. Recent major reports on the Great Lakes, such as those of the International Great Lakes Levels Board(1973) and the Canada-Ontario Great Lakes Shore Damage Survey(1975), recommend that greater emphasis be placed on nonstructural solutions to shoreline flooding and erosion, particularly land use regulation.

It can be expected that the modifications to existing policy described in this scenario will have important environmental implications. The possibility of subsidy for relocation and flood proofing, rather than strictly shore protection and rehabilitation of damaged buildings, and greater application of land use regulation will reduce the need for shore protection structures that may interfere with environmental processes and recreational and visual enjoyment of the shoreline. As well, the application of environmental guidelines and assessment procedures, such as under the federal environmental assessment and review process and Ontario Environment Assessment Act, and enforcement of environmentally sensitive shore protection permit programs would help to reduce the construction of biophysically disruptive protection works.

From an economic and social viewpoint, the modifications to existing north Erie shore hazard policy

envisaged in this scenario will reduce future damages through regulation of new development and shore protection and reduction of the hazard susceptibility of existing development, when opportunities for relocated or flood proofed reconstruction occur. Application of benefit-cost analaysis to major programs and projects would help to ensure economic efficiency. Equity guidelines would help to reduce large discrepancies in the distribution of benefits and costs of programs. For example, the association rule, which suggests that local program beneficiaries pay the proportion of total costs that local benefits bear to nonlocal benefits, might be applied to cost sharing for shore protection works or other adjustments.(8)

In terms of political and administrative considerations, the modifications to existing policy suggested in this scenario offer the opportunity for only minor improvements. A fixed shore elevation for shore protection permit programs would facilitate greater application of these programs to all protection works, not just those deemed to be on public land. As well, less emphasis on structural measures and greater application of economic, social and environmental guidelines might reduce somewhat the ad hoc and crisis nature of government response to hazard problems on the north Erie shore. However, this scenario does not envisage any major shift in the division of decision-making power among different agencies and levels of government. Consequently, many of the jurisdictional and

administrative problems inherent in existing policy will persist, including the temptation to resort to politically expedient, but ad hoc and crisis oriented, responses to storms and severe flooding and erosion.

Municipalities will be under increasing development pressure and are not likely to display a great deal of initiative in land use regulation, particularly at the local, as opposed to regional, municipal level. Land use regulation will not be politically acceptable to many shore property owners. In the absence of strong provincial encouragement otherwise, municipalities will continue to take a very narrow, local view of land use and other issues. Municipalities will look favourably on the tax benefits from increased shoreline development and select senior government hazard programs of greatest local net benefit. Indeed, senior governments facilitate this local view through divided and sometimes confused agency responsibilities. For example, a government agency, through its promotion of a power generation facility, may induce further growth and development pressure while other government agencies may be concerned over the need for public recreational shoreline or enhancement of environmental values. Similarly, government agencies may offer municipalities shoreline hazard programs which may conflict with the objectives of other agencies.

Finally, from a technological-informational viewpoint, the modifications suggested in this scenario offer some improvement over existing policy. A more environmentally

sensitve shore protection permit program would help to reduce the construction of ineffective private shore protection works. Further application of hazard land use regulations would provide an impetus for research and data collection on coastal processes and the delimitation of hazard lands along the shoreline. The Canada-Ontario Great Lakes Shore Damage Survey provided basic information in this direction and a more detailed local management study is now underway in Colchester South and Gosfield South Townships. This $120,000 study by Fisheries and Environment Canada and the Ontario Ministry of Natural Resources will consider structural and nonstructural adjustments to the shoreline hazard problem.(9)

In summary, the modifications to existing policy outlined in this scenario offer some opportunities for reducing future flood and erosion hazard damages on the north Erie shore without major shifts in decision-making power among agencies and levels of government. However, such opportunities are likely to be realized only in part, given the traditional reluctance of municipalities to be aggressive in the area of hazard land regulation. This suggests that perhaps new shoreline hazard policy is worth exploring.

New Hazard Policy for the North Erie Shore

New hazard policy for the north Erie shore might involve some shift in decision-making power between government agencies or levels of government. New arranagements might range from an agency concerned solely with natural hazards to one concerned with comprehensive coastal zone management.

The need for some coordination and rearrangement of existing government hazard functions was recognized to some extent during the 1972-1975 high water period. A private member's bill, the Flood Control Commission Act of 1973, was introduced into the Ontario Legislature in April, 1973.(10) This bill called for the creation of a seven member Flood Control Commission appointed by Cabinet to study water currents in the Great Lakes and how to protect shorelines from erosion, determine methods of protecting shorelines from flooding, present shore protection plans to property owners, suggests methods of flood proofing, consider the merits of flood insurance and consult with Conservation Authorities on hazard land regulation and acquisition. The Commission would report annually to the Minister of Natural Resources and be able to authorize any consulting studies to accomplish its objectives. The bill proposing this Commission did not receive legislative approval.

Further recognition of the need for some coordination of agency hazard functions is reflected in the

establishment, in 1973, of the Inter-Ministry Flood Damage Working Group to coordinate and deliver provincial shoreline hazard programs, disseminate information on these programs, allocate funds and resources and recommend new policy on hazards. Effort appears to have been concentrated on delivery of existing programs, particularly structural measures, with little consideration of new policy.(11) The Ministry of Housing, with responsibility for municipal official plans and zoning bylaws, was not a member of the Working Group.

Ideally, an agency concerned specifically with natural hazards should command a broad range of adjustments. Both the proposed Flood Control Commission and the Inter-Ministry Flood Damage Working Group fall short in this respect. For example, no provision was made in the Flood Control Commission legislation for cost sharing for land acquistion, flood proofing, relocation or shore protection works. In addition, a hazards-specific agency should be able to administer disaster relief, regulate development and shore protection in hazardous areas and coordinate flood warning and emergency measures. Furthermore, such an agency should base its decisions broadly on environmental, social, economic and technical information. The Province is the appropriate level of government for such an agency, as constitutional jurisdiction over most aspects of natural hazards, including land use regulation, ultimately stems from the Province.

Formation of a hazards-specific agency would be difficult, as shifts in agency decision-making would be necessary. Some centralization of provincial hazard functions within the Ministry of Natural Resources, however, has already occurred. The Emergency Measures Repeal Act of 1976, for example, dissolved the Emergency Measures Branch of the Ministry of the Solicitor-General. Some of the functions of this Branch have been assumed by the Ministry of Natural Resources. As well, the Ministry of Natural Resources, through local Conservation Authorities, can exercise some influence on land use regulation in shoreline areas.

A hazards-specific agency could formalize the modifications to existing policy suggested earlier in this Chapter. More stress could be placed on nonstructural adjustments and future damage could be reduced through regulation of new development and shore protection and reduction of the hazard susceptibility of existing development through relocated or flood proofed reconstruction. Potentially, establishment of a hazards-specific agency could curb increases in future hazard damages beyond the 1972-1975 level.

Natural hazards, however, are only one of several pressing shoreline problems. A hazards-specific agency would not be concerned with water quality, public recreation, fish and wildlife, aesthetics or land use conflicts. As a result, opportunities to realize multiple

benefits for the shoreline might be missed by an agency concerned strictly with natural hazards. Indeed, the responses of a hazards-specifc agency might exacerbate other shore problems. The potential inherent in a more comprehensive view of the shoreline is illustrated by the Turkey Point example.

Coastal Zone Management

A study of the Lake Erie community of Turkey Point in the Regional Municipality of Haldimand-Norfolk indicated that septic systems of the 700 cottages and homes are not functioning well in the low-lying sandy soil and are contaminating the lake and ground water.(12) The report recommended relocation of the entire community, with the exception of several commercial enterprizes, away from the lakeshore. The cost of relocation was estimated at $4,500,000 while the cost of servicing the community with sewers and water was $3,500,000. From the narrow perspective of solving the water pollution problem, it appears that servicing is the less costly alternative. However, the community is subject to flood and erosion problems. Property damages in 1973 exceeded $111,000 and it is estimated to cost $962,000 to protect the shoreline with reinforced concrete.(13) To protect roads in the community, some $118,000 was spent by the Province and township under the Special Emergency Assistance program between 1973 and

1975. Considering both the water pollution and natural hazard problem, relocation becomes more attractive. As well, relocation would permit expansion of the popular Turkey Point Provincial Park and could increase tourist spending in the area substantially. It has been estimated that the provincial and municipal governments derive tax revenues from tourism to the extent of 10% and 5%, respectively, of total tourist spending.(14) The Township would lose some tax revenue from relocation, as some cottagers would simply sell and not relocate in the township. This loss would be partially offset by provincial grants in lieu of taxation for the expanded park. Cottagers would lose direct access to the Lake, but would be removed from the recurring hazard problem. As well, there would be opportunities to enhance ecosystem values by allowing areas of former residential development to revert to a more natural state.

From a more comprehensive view of coastal problems, therefore, the alternative of relocation of the Turkey Point community becomes much more attractive. A narrowly-based decision to solve one problem may preclude opportunities to solve other problems. This will become particularly critical with respect to natural hazards and water pollution, as communities along the shoreline contemplate sewer and water services. The Canada-U.S. Agreement on Great Lakes Water Quality is facilitating the servicing of Great Lakes basin communities. Once shoreline communities

are serviced, the option of relocation to solve the hazard or any other problem is effectively closed given the large capital commitment to services... In turn, costly large scale shore protection may become necessary, representing a further commitment to continued occupance of hazardous shoreline areas. Large scale servicing along Michigan's highly flood susceptible Monroe County shoreline is already underway, effectively reducing the range of possible solutions to the hazard problem in that area.

The need to take a more comprehensive view of shoreline problems is also important with respect to recreation. The demand for public recreational shoreline in southern Ontario will continue to increase, and the Province will come under pressure to provide more public access to the Great Lakes shoreline.(15) A comprehensive view might suggest that funds for acquisition of recreational shoreline could be appropriately used to acquire hazard land, thereby satisfying two pressing shoreline problems.

Given the advantages inherent in a more comprehensive view of coastal problems, it is meaningful to consider potential mechanisms for introducing comprehensive coastal zone management on the north Erie shore. First, however, it is instructive to discuss several significant issues raised by the recent and extensive United States experience in coastal zone managementt.

Perhaps the major issue in coastal zone management concerns local-nonlocal control of land use. In both the

United States and Canada, land use regulation has been delegated largely to municipalities. As previously noted, municipal governments tend to view coastal problems from a narrow, local perspective often to the detriment of regional or national interests. Recognizing the need for a broader view, the United States Coastal Zone Management Act of 1972 requires that states exercise greater control over land use and related matters. To be eligible for federal financial assistance, state coastal zone programs must include one or more of the following control mechanisms: state establishment of criteria and standards for local implementation, subject to state review and enforcement; direct state land and water use planning and regulation; or state review of development proposals by any state agency, local government government or private developer, with power to approve or reject the proposal after public notice and an opportunity for hearings.

In addressing the issue of state versus local control of land use, Ducsik(1974) suggests that while a broader view is essential, wholesale state control is not the answer as many issues continue to be local in nature.(16) Other coastal zone researchers suggest that the sentiment for home rule is very strong and that much of the implementation of any coastal zone program must be, realistically, in the hands of local government.(17) These researchers, however, point to the need for state guidelines within which local governments must operate. Moreover, it must be clear what

standards are to be enforced and what agencies are responsible for enforcement. The consensus of many coastal zone management observers is that a balance must be struck between cooperation and coercion in local-nonlocal control of land and related water uses.

Recent experience with state involvement in land use regulation suggests that only limited success has been achieved in slowing down the rate of coastal development. Mitchell(1975) suggests that New Jersey's coastal management legislation has been "possibly effective in holding down large scale occupance in some of the most hazardous and valued ecosystems".(18) It appears that the great majority of permit applications under the Coastal Area Facility Review Act of 1973 are being approved. Mogulof(1975) reports that over 90% of permit applications have been approved by regional and state coastal commissions under the California Coastal Zone Coservation Act of 1972.(19) However, he notes that the commissions are increasingly using conditional permits to effect changes in the nature and scale of development.

A second major issue in coastal zone management concerns administrative fragmentation. A great many agencies at various levels of government are concerned with various aspects of the coastal zone. A popular response to this problem in the United States has been some form of coordinating body, with representatives of various agencies. The Florida Legislature, for example, established the

Coastal Coordinating Council in 1970, which united three state agencies with primary regulatory responsibility in the coastal zone.(20) In Delaware, the Governor's Task Force on Marine and Coastal Affairs(1974) has recommended the creation of an inter-agency coordinating mechanism.(21) Some coastal zone researchers have also suggested that a single agency or administrator could be responsible for all aspects of coastal zone management.(23)

The federal Coastal Zone Management Act of 1972 requires coordination of relevant federal agencies in the approval of state coastal zone plans. Once approved, federal agencies must exercise their permit granting authority in conformity with the state plan. Recognizing the need for coordination in another respect, a 1976 amendment to the Act provides 90% federal grants to promote coordination across state boundaries.

A third issue concerns administrative will to deal with complex coastal problems and public support for coastal zone management. While comprehensive coastal zone management will invariably be based in legislation, there must exist a willingness by government to administer the legislation, particularly in the area of enforcement of regulations, guidelines and standards. The sustained pressure of an enlightened public is the key here.(23) In California, for example, the coastal zone legislation was the result of a citizens initiative placed before voters. Moreover, environmental groups and concerned citizens have continued

to advocate conservation of the California coast. Upwards of 70% of the appeals to the State Coastal Commission are by environmental and neighbourhood groups and citizens as opposed to developers.(24)

The importance of sustained public pressure has been articulated by Sabatier..."A regulatory agency without an active, organized, supportive constituency is likely to be stricken with paralysis and deprived of power, an object of contempt to its enemies and of despair to its friends".(25) The cyclical nature of public interest in environmental and other problems, as expressed by Downs(1972), raises a less than encouraging implication for regulatory agencies.(26)

Coastal Zone Management on the North Erie Shore

In Ontario, several legislative enactments appear to have some potential as mechanisms for introducing comprehensive coastal zone management on the north Erie shore. The Ontario Planning and Development Act of 1973 represents potentially significant legislation in this respect. This Act authorizes the Minister of Treasury, Economics and Intergovernmental Affairs to establish any area in Ontario as a development planning area and direct the preparation of a plan "designed to promote the optimum economic, social, environmental and physical condition of the area".(27) The Minister is required to appoint at least two advisory committees, one representing planning area

municipalities and one broadly representing planning area citizens, to make recommendations on the preparation and implementation of the plan. The development plan may contain policies on population density, general location of industry and commerce, provision of parks and open space, acquisition of land, management of land and water resources, control of all forms of environmental pollution, location and development of infrastructure, development and maintanence of social facilities, financing of capital works, coordinating planning and development area municipalities and any other policies seen advisable by the Minister for implementation of the plan.

Upon completion of the plan, the Minister must ensure that each area municipality, interested citizens, and any advisory committees are furnished with copies of the plan and asked to comment. As well, the Minister must appoint a hearing officer for the purposes of conducting public hearings on the plan and recommending to the Minister the acceptance, rejection or modification of the plan in light of representations made to the hearing officer. Final approval of the plan rests with Cabinet who also approve, following public hearings, any amendments to the plan proposed by the Minister, any person or municipality.

Once the development plan has been approved, no municipality or Ontario government agency can undertake any structural or other undertaking or pass any bylaw that is in conflict with the plan. The development plan overrides local

official plans and zoning bylaws, which must be amended, if necessary to conform to the development plan.

Other important features of the Ontario Planning and Development Act include authorization for the Minister to acquire any land within the development planning area, subject to the Expropriations Act, dispose of any such land in any manner and provide financial assistance to any person, organization, corporation or municipality undertaking any policy or program that implements the plan. The Act also requires that the Minister undertake a review of the plan at least every five years, incorporating the same public hearing and plan approval process outlined. Although the Ontario Planning and Development Act has yet to be utilized, related legislation attempting to preserve the Niagara Escarpment has been applied.

The Niagara Escarpment Planning and Development Act of 1973 establishes a system of development control over the 450 mile Niagara Escarpment for the maintenance of this unique resource as a "continuous natural environment and to ensure that only such develpment occurs as is compatible with that natural environment".(28) The Act authorizes the preparation and approval of a Niagara Escarpment plan in a manner, and with objectives, similar to the Ontario Planning and Development Act. As with the Ontario Planning and Development Act, provision is made in the Escarpment legislation for land acquisiton and financial assistance to

individuals, corporations and municipalities to implement the policies of the plan.

Unlike the Ontario Planning and Development Act, however, the Niagara Escarpment Act specifies a system of development control whereby each and every application for development within the development control area is evaluated on its own merits in terms of its compatibility with the Escarpment and policies of the plan. Until a plan is approved, a Niagara Escarpment Commission established by the Act is reviewing applications for development with respect to type of use, siting and design, colour of buildings, landscaping, grading of site and other factors. The Commission approves or rejects applications for development, with an appeal procedure to the Minister of Housing, responsible for the Act. Once the plan is approved, it is envisioned that the Commission's responsibilities for administering development control will be transferred to county and regional municipal governments.(29)

A third body of legislation with some potential as a vehicle for introducing coastal zone management on the North Erie shore is the Conservation Authorities Act of 1946, as amended. This Act authorizes Cabinet to establish local conservation authorities, usually on a watershed basis, following a request by municipalities involved. The local conservation authority is a coporate body whose members are appointed by the member municipalities, and Cabinet if the authority receives provincial grants. Conservation

authorities and their projects are financed by member municipalities and are eligible for grants from the Ministry of Natural Resources.

The objectives of the conservation authorities are to "further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals."(30) Authorities have the power to acquire and dispose of land, control the flow of surface waters, alter watercourses and make regulations(subject to Cabinet approval) on the use of water, altering watercourses, land filling and any construction in a pond, swamp or land susceptible to flooding.

Comprehensive coastal zone management could incorporate the modifications to existing north Erie shore hazard policy previously outlined. Application of environmental impact analysis and environmentally sensitive regulation of shore protection works and more emphasis on nonstructural adjustments such as relocation, land acquisition and hazard land use regulation would have favourable environmental implications. From an economic and social viewpoint, application of economic efficiency and equity guidelines, regulation of new hazard land development and shore protection works and reduction of hazard susceptibility of existing development would reduce future hazard damages. From a technological and informational perspective, greater efficiency in private protection works could be achieved through regulation of shore protection based on an adequate

understanding of coastal processes. As well, greater emphasis on hazard land use regulation would encourage an improvement in understanding of degrees of risk and extent of hazard susceptibility along the shoreline.

It is in the area of political and administrative considerations, however, that coastal zone management offers significant potential over the modifications to existing policy outlined earlier in the Chapter. A more comprehensive and rational approach to shoreline problems affords the possibility of reducing reliance on politically motivated ad hoc and crisis response adjustments to natural hazards. A firm commitment to a long term management plan for the shoreline with emphasis on nonstructural adjustments should help reduce the necessity of turning to expedient structural 'solutions' in times of crisis.

Coastal zone management also offers an opportunity for rational decision-making on hazard problems in light of other pressing shoreline problems such as recreation and environmental pollution. In this respect, the Ontario Planning and Development Act and the Niagara Escarpment legislation are particularly attractive given their rather comprehensive mandate to consider economic, social and environmental conditions in plan preparation. While these Acts require that the actions of individuals, corporations, municipalities and provincial agencies must conform to the plan, they do not involve any restructuring of provincial agencies or redistribution of agency functions. Moreover,

they do not provide a mechanism for incorporating the functions of federal agencies, of which the Departments of Fisheries and Environment, Transport and Public Works are of some significance in shoreline matters.

However, extensive agency and functional restructuring may be neither necessary nor desirable in effecting a more comprehensive approach to coastal problems.(31) Certainly the constitutional implications of concentrating federal and provincial functions within a single agency are ponderous. Moreover, the United States experience suggests that the major issue in coastal zone management, at least from the viewpoint of natural hazards, is local-nonlocal regulation of development which is beyond direct federal involvement in both the United States and Canada. Furthermore, effective regulation of development has important implications for other coastal problems such as pollution. Given the importance of regulation of land use and development and the constitutional limitations on federal involvement in this major issue, the Province becomes a 'core actor' in any attempt to introduce coastal zone management on the north Erie shore.

Greater federal-provincial cooperation and coordination will be necessary in any attempt to comprehensively manage the shoreline, as Johnston and others(1975) stress in their report on frameworks for coastal zone management in Atlantic Canada.(32) In this regard, the Canada Water Act authorizes the Minister of Fisheries and Environment to enter into

agreements with provinces for comprehensive water resource management in waters of national significance. Certainly the Great Lakes qualify for consideration, as reflected in the Canada-Ontario-Great Lakes Shore Damage Survey.

Any form of coastal zone management for the north Erie shore will be difficult to effect and may not be close at hand, given issues of local-nonlocal development control, administrative fragmentation and public support. The political controversy surrounding provincial imposition of development control on the Niagara Escarpment supports this contention. Development control on the Escarpment has generated widespread local opposition and most staff recommendations for permit rejection have been overruled.(33) In excess of 85% of development permit applications have been approved.

The Niagara Escarpment experience, in fact, may deter provincial action on regulation of shoreline areas. The Province, for example, has yet to issue any kind of policy statement on the significance, use and management of Ontario shorelines. There exists some danger that, in the absence of overall provincial shoreline policy, some regional municipalities and other local jurisdictions will develop their own shoreline policies. These may or may not be compatible with a provincial policy that ultimately may emerge. The development of a shoreline policy by the Regional Municipality of Haldimand-Norfolk lends weight to this observation.

Conclusions

A consideration of future scenarios illustrating the implications of broad strategies for adjusting to flood and erosion hazards on the north Erie shore suggests the following conclusions:

First, continuing with hazard policy as expressed during the 1972-1975 and earlier high water periods on the north Erie shore will be costly in terms of damages sustained and government hazard assistance expended. It is estimated that potential single year shore damages in excess of $7,600,000 (in 1973 dollars) can be expected by the 1990's if hazard land encroachment continues. Related government expenditures could exceed $8,000,000. Moreover, these expenditures would not guarantee any reduction in damages from subsequent storms or high water periods. The cycle of damages sustained and government funds expended will simply continue under existing hazard policy.

Second, modifications to existing flood and erosion hazard policy on the north Erie shore offer potential for reducing future damages and government expenditures. A number of relatively incremental changes could be made in existing policy. Specifically, the federal and provincial governments could: make grant and loan programs providing assistance to shore property owners on the north Erie shore more flexible to facilitate relocation and flood proofing of hazard susceptible structures; broaden the basis on which

decisions are made to implement programs and projects addressing north Erie shore hazards to include economic, social and environmental, as well as technical, considerations; enforce existing shore protection permit procedures with particular attention to determining the environmental suitability of proposed protection works; and facilitate and encourage municipal governments to regulate development in shoreline areas, particularly areas such as Malden, Colchester South, Gosfield South, Mersea, Harwich, Norfolk, Delhi, Nanticoke and Haldimand Townships(see Figure 14) which are highly hazard susceptible and likely to come under increasing development pressure.

To facilitate hazard land regulation, appropriate federal and provincial agencies could provide municipalities with expertise on coastal processes and detailed delimitation of flood and erosion hazard land.

And third, if federal and provincial government agencies have an administrative will to reduce flood and erosion damages and, ultimately, government hazard assistance, much could be accomplished through modifications to existing hazard policy described above. The introduction of comprehensive coastal zone management, while a more formidible challenge, presents an opportunity to deal with the range of pressing problems, including water pollution and public recreational access, affecting Ontario shorelines. As land use regulation appears to be a central element in coastal zone management, the province must take a

lead in this area. As a first step, the Province must give consideration to development of a shoreline policy outlining the environmental and economic significance of Ontario shorelines and identifying the biophysical and human functions these shorelines should satisfy. For example, some economic activities clearly require a shore location while others do not. As a second step, thought must be given to means of introducing planning and management schemes that will permit a satisfaction of demands for both preservation and development. Existing legislation, such as the Ontario Planning and Development Act, should be examined in detail as possible vehicles for coastal zone management or, at the minimum, coastal hazard management on the north Erie shore. While the Province should exercise the lead in this regard, an opportunity for federal-provincial cooperation in coastal zone management is present in the Canada Water Act. The Canada-Ontario Great Lakes Shore Damage Survey has been an initial expression of this opportunity.

NOTES

[1] Dollar figures are adjusted using the Engineering News-Record construction cost index. For unadjusted data see Chapter III, Tables 4 and 5.

[2] Canada-Ontario Great Lakes Shore Damage Survey, Technical Report (Environment Canada and Ontario Ministry of Natural Resources, 1975), p. 44.

[3] On the north Erie shore, private agricultural, recreational and vacant land was converted to residential and commercial uses at an annual rate of 1.8%. See, Task Force on Available Shore Erosion Information, Shore Erosion on the Great Lakes-St. Lawrence System, Part 2: Shore Erosion on the Great Lakes System (Government of Canada, 1973), p. 30; Canada-Ontario Great Lakes Shore Damage Survey, Report, p. 43.

[4] Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix 12: Shore Use and Erosion (Ann Arbor: Great Lakes Basin Commission, 1975), p. 76.

[5] I. Orchard, Environment Canada, Toronto, Personal Communication, November 29, 1976.

[6] "Background Notes on Proclamation, Regulations and Exemption Orders Under the Environment Assessment Act", EA Update, Ontario Ministry of the Environment, 1, No. 1 (1976), 2; "Interim Exemptions Expire", EA Update, Ontario Ministry of the Environment, 2, No. 2 (1977), 3.

[7] P. Hale, Regional Municipality of Haldimand-Norfolk, Cayuga, Personal Communication, June 10, 1977.

[8] H.E. Marshall, Cost Sharing for Shoreline Protection (Fort Belvoir, Virginia: U.S. Army Engineer Institute for Water Resources, 1974), p. 52.

[9] W.S. Haras, Canada Centre for Inland Waters, Burlington, Personal Communication, July 21, 1977.

[10] Ontario, Legislature, Debates, April 2, 1973 (Toronto: Queen's Printer, 1973", p. 423.

[11] D.R. Fortner, Ontario Ministry of Natural Resources, Chatham, Personal Communication, February 19, 1975. The Flood Damage Working Group did consider as new policy the adoption of flood insurance.

[12] Haldimand-Norfolk Lakeshore Study, A Lakeshore Study of Haldimand and Norfolk Counties (n.p., 1973), pp. 44 and 98-99.

[13] Canada-Ontario Great Lakes Shore Damage Survey, Technical Report (Environment Canada and Ontario Ministry of Natural Resources, 1975), pp. 57 and 94.

[14] P. Klopchic, Taxes and Other Government Revenue Generated by Tourist Spending (1968) and the Need for Further Investment in the Ontario Tourist Plant (Toronto: Ontario Department of Tourism and Information, 1971), p. 3.

[15] See, for example, London Free Press, January 24, 1974; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs, Provincial Financial Assistance to Municipalities, Boards and Commissions (Toronto: Ministry of Treasury, Economics and Intergovernmental Affairs, 1975), p. 32.

[16] D.W. Ducsik, Shoreline for the Public (Cambridge, Massachusetts: Massachusetts Institute of Technology, 1974), pp. 211-214.

[17] See, for example, O.A. Collver, "The Changing Role of Local Government", in New York Sea Grant, Proceedings of a Conference on Coastal Zone Management (Albany, New York, 1973), p. 60.

[18] J.K. Mitchell, "Coastal Management from a New Jersey Perspective" (paper presented to the American Association for the Advancement of Science, New York, January 26-31, 1975), p. 5.

[19] M.B. Mogulof, Saving the Coast (Lexington, Massachusetts: D.C. Heath, 1975), p. 41.

[20] T.E. Lewis, "Coastal Zone Management--The Florida Experience", Shore and Beach, 41, No. 2 (1973), 12.

[21] Governor's Task Force on Marine and Coastal Affairs, The Coastal Zone of Delaware (Newark: University of Delaware, 1971), p. 335.

[22] See, for example, M.J. Hershman, "Coastal Zone Legislation in the States", in New York Sea Grant, Proceedings, pp. 16-17.

[23] Ibid., p. 18.

[24] Mogulof, Saving, p. 46.

[25] P. Sabatier, as quoted in Mogulof, Saving, p. 29.

[26]A. Downs, "Up and down with ecology--the 'issue-attention cycle'", The Public Interest, 28 (1972), 38-50.

[27]Ontario, The Ontario Planning and Development Act, 1973, office consolidation (Toronto: Queen's Printer, 1974), p. 1.

[28]Ontario, The Niagara Escarpment Planning and Development Act, 1973, office consolidation (Toronto: Queen's Printer, 1974), p. 2.

[29]"The Niagara Escarpment", Ontario Planning Newsletter, Ontario Ministry of Treasury, Economic and Intergovernmental Affairs, (September, 1973), 1.

[30]Ontario, The Conservation Authorities Act, office consolidation (Toronto: Queen's Printer, 1973), p. 11.

[31]D.M. Johnston and others, Coastal Zone: Framework for Management in Atlantic Canada (Halifax: Dalhousie University, Institute of Public Affairs, 1975), pp. 149-163.

[32]Ibid.

[33]R. Chrystian, Niagara Escarpment Commission, Grimsby, Personal Communication, November 26, 1976. For examples of local opposition to development control, see, Wiarton Echo, November 6, 1975, July 15, 1976.

CHAPTER VII

SUMMARY

This disseration, essentially an examination and evaluation of Lake Erie shoreline flood and erosion hazard policy, has attempted to satisfy five objectives. First, a model for evaluating natural hazard policy is developed. Second, the nature of the Erie shoreline flood and erosion hazard problem is defined from a human ecological perspective. Third, government policy goals and means of satisfying these goals on the Erie shoreline are identified. Fourth, Erie shoreline hazard policy is evaluated in terms of environmental, socio-economic, political-administrative and technological-informational criteria. And fifth, the implications of several broad policy approaches to north Erie shoreline flooding and erosion are discussed.

A Natural Hazard Policy Evaluation Model

The natural hazard policy evaluation model developed in this disseration involves four steps. First, the hazard policy problem is defined in terms of the nature of the hazard and its magnitude and frequency. Second, hazard policy goals of economic efficiency, environmental quality and social well-being are identified, as are means of reducing hazard losses, redistributing these losses or doing nothing. Third, environmental, socio-economic, political-administrative and technological-informational evaluation criteria are specified. And fourth, these evaluation criteria are applied to a wide range of hazard policies that attempt to reduce hazard losses, redistribute these losses or do nothing and let individuals reduce or bear the losses.

Evaluation criteria are essential to the methodology and a number of hazard policy issues are identified. In terms of environmental considerations, hazard policy should minimize impacts on the biophysical environment, recreation and aesthetics. To accomplish this, environmental impact analysis should be required or other environmental guidelines specified. With regard to social and economic aspects, hazard policy should reduce damages and discourage continued hazard susceptible development. As well, hazard land occupants should bear an equitable portion of the costs of hazard land encroachment. Benefit-cost analysis should

be required or efficiency and equity guidelines specified. In terms of political and administrative considerations, hazard policy should be sensitive to the concerns of affected individuals and provide for public input and appeal of decisions. Policy should not be an ad hoc response to crisis and jurisdictional and administrative problems in policy application should be minimized. With respect to technological and informational factors, hazard policy should be efficacious, based on adequate information, techniques and guidelines to encourage effectiveness. As well, there should be provision for hindsight evaluation of policy.

Defining the Hazard Policy Problem

In this dissertation, the Lake Erie shoreline flood and erosion hazard problem is defined in terms of a human ecological concept of natural hazard. This concept stresses that hazards result from the interaction of biophysical elements and processes. Thus, factors such as lake level fluctuation, beach material composition and the nature and extent of human encroachment are important components of the Erie shoreline hazard system.

Flooding of shoreline areas can result from long term, annual and short term fluctuations in the level of Lake Erie. Short term fluctuations, due to meteorological disturbances, are particularly damaging when they occur

during periods of long term high lake levels. Periods of high lake levels recur roughly every fifteen or twenty years on Lake Erie, most recently during the 1972-1975 period. The low lying Erie sand spits and Erie's Western Basin shoreline are particularly susceptible to flooding.

Much of the Erie shoreline is composed of erodible unconsolidated material such as sand or glacial till. Average annual shore recession rates of 18 feet have been recorded along the Erie shoreline in Elgin County. The sand spits and Lake Erie's Central Basin shoreline are susceptible to erosion, particularly during periods of high lake levels and severe storms.

The Erie shoreline has been an attractive location for various human activities and presently some 44% and 52% of the north and south Erie shorelines, respectively, are developed in permanent and seasonal residential, commercial and industrial uses. Much of this development has been concentrated in hazard susceptible areas such as the sand spits and Western Basin shoreline, in spite of the existence of lake level data since 1860. As a consequence of this hazard land encroachment, 1972-1975 property damages on the north and south Erie shores were $6,200,000 and $104,000,000, respectively. Evidence indicates that damages are increasing, largely due to increasing hazard susceptible encroachment.

The history of hazard adjustment in the Pelee, Rondeau, Long Point and Presque Isle areas indicates that shore

protection works have been the preferred response to flooding and erosion. Man has attempted to interfere with biophysical processes and 'fix' dynamic shorelines. This approach has resulted in a long history of recurring and increasingly costly measures to combat shoreline hazards. Moreover, the greater proportion of adjustment costs are being borne increasingly be the wider taxpaying public as the level of senior government cost sharing increases.

Important environmental costs have been associated with hazard land encroachment in the sand spit areas. Many acres of ecologically valuable marsh have been drained for agriculture and filled for residential use. Some shore protection works interfere with littoral processes, accelerating erosion in adjacent areas. During high lake levels in particular, septic systems associated with residential and commercial uses contaminate lake water.

The history of human encroachment and adjustment to flooding and erosion in the Pelee, Rondeau, Long Point and Presque Isle areas suggests that generally man has ignored or neglected coastal processes and the implications of these processes on human activities.

Natural Hazard Policy and Policy Goals

Governments can pursue three basic policies with respect to natural hazards. Governments can attempt to: reduce hazard losses through a variety of structural and

nonstructural means; redistribute these losses among taxpayers generally; and do nothing and let individuals cope with hazards on their own. Goals of economic efficiency, environmental quality and social well-being appear to underlie these broad policy approaches.

A variety of means are available to adjust to flood and erosion hazards on the Erie shoreline. In pursuing a policy of reducing hazard losses, governments can modify the hazard cause, modify the hazard or modify the loss potential. Lake level regulation, seawalls and hazard land use regulation are examples of these types of policy. In pursuing a policy of redistributing hazard losses, governments can provide public disaster relief or tax write-offs. In doing nothing, governments bear the losses on public property and let individuals contend with private property losses.

An important feature of Lake Erie shoreline hazard policy is the highly fragmented nature of administrative arrangements. There are at least 54 international, federal, provincial, state, interstate and federal-state agencies attempting to reduce or redistribute Lake Erie flood and erosion hazard losses, as well as 31 incorporated municipalities in Ontario and 61 in Michigan, Ohio, Pennsylvania and New York bordering Lake Erie. Various regional and special purpose bodies, such as conservation authorities and planning areas, further complicate the formulation and expression of hazard policy on the Erie shoreline. Moreover, evidence suggests that administrative

arrangements are becoming increasingly complex with the establishment of new agencies.

In spite of the fact that some agencies such as the United States Army Corps of Engineers, Canada Department of Fisheries and Environment and Ontario Ministry of Natural Resources are more centrally involved in Erie shoreline hazards, no single agency commands a wide range of means for dealing with flood and erosion hazards. For example, federal agencies have no direct control over land use, which is a provincial and state function that has been delegated, in turn, to municipal governments.

A second important feature of Lake Erie shoreline hazard policy is the often crisis generated and ad hoc nature of government response to flooding and erosion. Typically, government responds to major storms on Lake Erie with ad hoc financial or other arrangements. This is particularly true on the north Erie shore, where much senior government policy is administratively, rather than legislatively, based.

The crisis response nature of decision-making and fragmentation of agency responsibilities have facilitated a structural appraoch to Erie shoreline hazards. Senior governments have financial power while local governments control development on hazard land. During times of crisis, senior governments are under considerable pressure to take some action. Typically, cost sharing arrangements for shore

protection attractive to local governments have been an expedient 'solution'.

Hazard Policy Evaluation

Selected policies that aim to reduce Erie shoreline hazard losses and redistribute these losses are evaluated in terms of environmental, socio-economic, political-administrative and technological-informational criteria. As well, the implications of a do nothing policy are considered.

Policies that attempt to reduce hazard losses by modifying the hazard and hazard cause address biophysical elements and processes. Consequently, structural measures such as lake level regulation and shore protection works can have important environmental implications. Structural adjustments are costly, not always effective in the long term and encourage continued occupance of hazard land. As well, structural measures often require a long term commitment to maintenance and reconstruction. For example, there is a long history of construction and reconstruction of shore protection works in the Pelee and Rondeau areas.

Generally, shore protection works are acceptable to shore property owners suffering flood and erosion damages, particularly when a high proportion of the costs of structures are borne by the wider taxpaying public. However, 1973-1974 A.R.D.A. dyking in Essex and Kent Counties and

Corps of Engineers temporary dyking in Monroe County generated considerable local controversy. In both cases, some shore property owners felt they were denied access to decision-making affecting them.

During the 1972-1975 high water period, in excess of $6,400,000 and $15,200,000 were spent by senior governments for shore protection on the north and south Erie shore, respectively. This represents 95% and 26%, respectively, of total measurable government flood and erosion hazard expenditures on the north and south shores during this period.

Policies aimed at reducing hazard losses by modifying the loss potential address human elements and processes in the natural hazard system. They seek to reduce, rather than increase, interaction between man and his biophysical environment. For example, hazard land zoning might exclude construction in highly hazardous shore areas. Similarly, a flood proofing policy might allow construction of hazard tolerant structures. By reducing interaction between human and biophysical processes, policies that modify the loss potential create opportunities for reducing future hazard losses.

Unfortunately, policy aimed at modifying the loss potential generally is not acceptable to shore property owners. While there has been little emphasis on this approach on the Lake Erie shoreline, particularly on the south shore, interest is increasing. The Michigan

shorelands management program and the adoption of official plan hazard policies by Ontario municipalities are examples of recent interest in hazard land use regulation.

Policies aimed at redistributing hazard losses do not address directly either the human or biophysical processes invovled in natural hazards. These policies simply spread the costs of hazard land encroachment among taxpayers generally. Inasmuch as programs such as the Ontario Post Disaster Assistance program and United States Small Business Administration disaster loan program do not attempt to reduce hazard losses, they can be economically inefficent responses to frequently recurring hazards. In Estral Beach, for example, residents received S.B.A. loans and grants three times during the 1972-1973 period to repair their earlier repairs. Hazard loss redistribution policies are very acceptable to propety owners and permit their continued occupance of hazardous shore areas.

Disaster relief has been stressed on the south Erie shore, where the application of several relief programs and tax write-offs resulted in government expenditures of over $41,900,000, or 73% of total measurable hazard assistance, during the 1972-1975 period. Disaster relief was not stressed on the north Erie shore.

A do nothing policy generally is not acceptable to shore property owners, yet from a broader perspective this approach may be a least cost solution. The south Erie shore experience suggests that any extention of disaster relief on

the north shore, for example making cottagers eligible, would prove costly to Ontario and possibly Canadian taxpayers generally.

While this evaluation identifies many problems concerning particular policies, it is possible to generalize. Many policies lack flexibility. Disaster relief programs do not allow or encourage relocated or flood proofed reconstruction of buildings. As well, policies lack provision for land acquisition. Thus opportunities for reducing future hazard losses are missed. At the same time, some policies lack guidelines to ensure efficiency, equity and effectiveness. For example, 1973-1974 90% senior government A.R.D.A. assistance was essentially a gift of funds to several municipalities with few guidelines attached. Municipalities were not required to consider whether the benefits of dyking projects would outweight costs. Nor were they required to consider the environmental or other implications of their projects.

In summary, government response to the 1972-1975 high water period on Lake Erie was costly. Total measurable government hazard expenditures during this period are estimated to exceed $6,800,000 and $58,300,000, respectively, on the north and south Erie shores. Public subsidies to private property owners are estimated to be $4,500,000 and $49,900,000, or 79% and 60% of total private damages, respectively, on the north and south shores. Yet, seldom does the general public derive benefits, for example,

in the form of increased recreational access to shorelines. the loss potential.

Hazard Loss Reduction

It is possible to consider the implications of several broad strategies for adjusting to flood and erosion hazards on the north Erie shore. Three future scenarios identified in this dissertation are: continuing with existing hazard policy; modifying existing hazard policy; and introducing new hazard policy.

The scenario of continuing with existing hazard policy on the north Erie shore suggests that if a high water period recurs in the 1990's, shore property damages could exceed the level incurred during 1972-1975 by at least 71%. This would result from a policy that attempts to modify biophysical processes rather than minimize the loss potential through measures such as relocation, flood proofing, hazard land acquisition and hazard land use regulation. Following severe storms, it can be expected that senior governments would respond to requests from property owners and municipalities for shore protection and dissater relief. Large government subsidies would benefit relatively few individuals in specific areas. Decisions to provide these subsidies would not be broadly based on environmental, economic or social guidelines and would

further reinforce the long term commitment to periodic subsidies.

The scenario of modifying existing north Erie shore hazard policy envisages changes that could reduce long term total hazard costs.

A first modification involves changes in grant and loan programs providing shore protection and rehabilitation assistance to property owners. The Ontario Post Disaster Assistance program, Ontario Shoreline Property Assistance program and Canada Department of Public Works erosion contributions program could be more flexible to permit relocation or flood proofing, as well as shore protection and rehabilitation to predisaster condition.

A second modification involves the application of economic, social and environmental, as well as technical or engineering, considerations to the selection, planning and implementation of programs. Such guidelines might help reduce the construction of environmentally disruptive or economically inefficient shore protection works and encourage consideration of nonstructural alternatives.

A third modification to existing north Erie shore hazard policy involves enforcement of federal and provincial shore protection permit programs. The enforcement of an environmentaly sensitive permit program would help reduce the construction of ineffective, environmentally disruptive and visually unaesthetic private protection works.

A final modification suggested in this scenario concerns the regulation of development in hazardous north Erie shore areas. Any reduction in hazard susceptible development can be expected to reduce future hazard losses. Particular attention should be focussed on hazard land regulation in areas such as Malden, Colchester South, Gosfield South, Mersea, Harwich, Norfolk, Dehli, Nanticoke and Haldimand Townships(see Figure 14), which are highly susceptible to flooding and erosion and subject to increasing development pressure.

These modifications to existing north Erie shore hazard policy offer some opportunities for reducing flood and erosion damages and, ultimately, government hazard assistance. However, new policy, specifically comprehensive coastal zone management, presents an opportunity to deal with the range of pressing problems, including water pollution and public recreational access, affecting the north Erie shore. A broader view of shoreline problems might suggest management solutions that can achieve multiple benefits, for example reduced hazard susceptibility and increased public recreational shoreline.

A central element in coastal zone management is land use regulation. The Province must take the lead here, given constitutional constraints on federal action in this area. As a first step, the Province should develop a shoreline policy outlining the environmental and economic significance of Ontario shorelines and identifying biophysical and human

functions these shorelines should satisfy. For example, not all human activities require a coastal location. As a second step, thought should be given to mechanisms for introducing planning and management schemes that will permit satisfaction of demands for both preservation and development. Existing legislation, such as the the Ontario Planning and Development Act of 1973, might represent one such mechanism. As several federal agencies have significant involvement on the north Erie shoreline, federal-provincial cooperation and coordination should be encouraged, possibly through provisions in the Canada Water Act of 1970.

Implications for Further Research

Initially, it was suggested that this dissertation can increase understanding of how man adjusts to his biophysical environment, a theme that has long captured the attention of geographers. Specifically, this case study of Lake Erie shoreline flood and erosion hazard policy demonstrates the significance of public policy in several respects. First, various government agencies undertake projects that affect shoreline ecology in the broadest sense, that is both biophysical and human processes. Second, government agencies facilitate or inhibit various adjustments to shoreline hazards by individual hazard land occupants and other government agencies. Administrative fragmentation appears to be a major problem in this respect. Each agency

and level of government has specific mandates with respect to shoreline hazards.

The conclusion that public policy is a very significant factor in human adjustment to coastal hazards supports recent findings of other natural hazard researchers. Heikoff(1975) suggests that intergovernment relations may prove one of the major limiting factors on attempts to manage coastal resources.(1) He documents how federal-state-local relations modified a technically 'best' structural solution to coastal erosion on Long Island, New York, and in doing so, exacerbated the hazard problem. With respect to a different natural hazard, Jackson(1965) has found that provision of disaster relief for earthquakes in the United States discourages the adoption of private adjustments.(2)

The development of any detailed theory of how man adjusts to his biophysical environment will have to recognize the importance of public policy and consider such factors as administrative fragmentation, crisis response and cost sharing arrangements, in addition to perceptual factors that have been explored well in the hazard literature.

This dissertation suggests that if governments wish to seek a reduction in shoreline flood and erosion damages at minimum long term total cost, emphasis must be placed on policies that aim to modify the loss potential, that is, reduce the interaction between human and biophysical processes at work along the shoreline. More detailed

research on the implications of specific programs and projects will be necessary. The evaluation criteria specified in this dissertation should prove a useful starting point. For example, what are the environmental, social, economic, political and technological implications of flood proofing as opposed to shore protection in a particular area? The recent United States Army Corps of Engineers shoreline flood protection study for Monroe County is an example of a more detailed consideration of structural and nonstructural flood adjustment possibilities.(3) This study determined that from the perspectives of national economic efficiency and environmental quality, flood proofing and relocation, respectively, were preferrable to adjustments such as shore protection, flood insurance and lake level regulation. A further example is the Canada-Ontario shore management study currently underway in Essex County.(4) This $120,000 study by Fisheries and Environment Canada and the Ontario Ministry of Natural Resources is a follow up to recommendations made in the Canada-Ontario Great Lakes Shore Damage Survey and will evaluate structural and nonstructural shore management alternatives for this particular shore reach.

While this dissertation has considered flooding and erosion, other natural hazards have important implications for human use of shorelines. On the Lake Erie shoreline, for example, low lake levels and deposition create inconvenience for many shore property owners and add greatly

to the costs of recreational and commercial harbour maintenance. Many of the biophysical and human processes and public policy implications discussed in this thesis may well apply to these hazards. For example, crisis response may be an important factor in human adjustment to low lake levels.(5) The involvement of power generation and commercial shipping interests may generate considerable pressure on senior governments to respond with large expenditures on harbour and channel dredging and lake level regulation. The general model developed in this disseration could provide a basis for evaluating these and other natural hazards.

Investigation of biophysical and human processes at work during low lake level periods would add greatly to an understanding of the total human ecology of Lake Erie hazards. Losses incurred during high water stages may be partially offset by benefits, such as increased recreational beach capacities, accruing during low water stages. Such an investigation might suggest refinements in both the hazard policy evaluation methodology and recommended policy changes.

NOTES

[1]J.M. Heikoff, Politics of Shore Erosion: Westhampton Beach (Ann Arbor: Ann Arbor Science Publishers, 1976), p. vi.

[2]E.L. Jackson, "Impact of Public Policy on Private Response to Hazard" (paper presented to the Ontario Division of the Canadian Association of Geographers, Carleton University, Ottawa, March 8, 1975), pp. 11-19.

[3]United States Army Corps of Engineers, Shoreline Flood Protection Study Monroe County, Michigan (Detroit: U.S. Army Engineer District, 1975).

[4]W.S. Haras, Canada Centre for Inland Waters, Burlington, Personal Communication, July 21, 1977.

[5]The International Joint Commission of the Great Lakes levels initiated in 1964 was largely a response to low water conditions at that time. See, International Joint Commission, Further Regulation of the Great Lakes (n.p., 1976), p. 1.

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