Heritage Resources Centre
Centre des ressources du patrimoine

Shoreline Flooding and Erosion Hazards in the Long Point Area

Long Point Environmental Folio
Publication Series

Working Paper 7

Long Point Environmental Folio Publication Series
Managing Editors: J. Gordon Nelson and Patrick L. Lawrence

A study team at the Heritage Resources Centre is developing an Environmental Folio for the Long Point Biosphere to assist management agencies and local citizens in understanding the human and natural components of the ecosystem. The folio will consist of a series of maps and text that would outline current major management issues and areas of concern. A series of project publications is being prepared to accompany the folio. These reports will consist of supplementary information collected during the study. This project is supported by the Royal Canadian Geographic Society and the Social Sciences and Humanities Research Council of Canada.

Shoreline Flooding and Erosion Hazards in the Long Point Area

Patrick L. Lawrence
and
J. Gordon Nelson

Long Point Environmental Folio
Publication Series

Working Paper 7

Heritage Resources Centre
University of Waterloo

August, 1994

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PHOTOS

LIST OF TABLES

SUMMARY

The Lake Erie basin is subject to severe shoreline flooding and erosion as a result of influences such as shoreline landform types, orientation of the lake, wind and wave action, fluctuating water levels, beach and bluff sediments, and the presence of shore protection structures. During the last thirty years numerous climatic events have resulted in conditions conducive to rapid rise in water levels in locations characterized by gentle nearshore profiles and exposure to wave action. In addition increased human activities, in the form of roadways, residential and industrial development have occurred along the north-central Lake Erie shoreline, including the low lying peninsulas of Point Pelee, Rondeau and Long Point. High lake levels and storms led to severe property damage in all these areas in 1951/52, 1954, 1955, 1958, 1969, 1972/73 and 1985/86. At Long Point, severe wind and water damage has occurred at properties along Hastings Drive and lakeshore roads. The damages to properties and roadways have increased greatly in conjunction with rapid infilling of shore areas and construction in the community of Long Point over the last three decades. Despite continual federal, provincial and local initiatives, including municipal land use and planning controls, increased development and investment in housing has been allowed to continue in areas subject to flooding and erosion. Within the Long Point region, current and future land uses are in conflict with these hazards in sites at Hastings Drive, first tier lakeview Long Point cottages, Provincial Crown Marshes, Long Point causeway, and Turkey Point.

ACKNOWLEDGMENTS

Assistance with data and information was provided by Mary Elder, Regional Municipality of Haldimand Norfolk; Reid Kreutzwiser, University of Guelph; Jim McIntosh, Township of Norfolk; and Glen Richardson, Township of Delhi; and several additional agencies including Environment Canada, International Joint Commission, Ontario Ministry of Natural Resources (Simcoe office), and the Long Point Region Conservation Authority. Ron and Deb Stenson and Andy Skibicki assisted with map preparation. The Long Point Environmental Folio project is supported by funding from research grants provided by the Royal Canadian Geographical Society and Social Sciences and Humanities Research Council of Canada to Dr. J. Gordon Nelson, study director. The results and opinions within this report are those of the authors and do not necessarily represent those of individuals and agencies contacted during this study.

INTRODUCTION

Understanding shoreline processes, human activities, adjustments to hazards, and management and planning responses is essential to developing proper policies and actions to reduce the risk of flooding and erosion to property and life. We need to understand more about the nature of flood and erosion hazards, their history and the variety of available solutions such as shoreline protection and land use planning, which are not working effectively. We must consider more options for reducing costs from these hazards in the future. The intention of this report is to help people to do this by presenting useful information on shoreline flooding and erosion hazards. Existing data sources, previous studies, and mapping are used to identify the severity of flooding and erosion currently, and within the recent past. This information will be presented at three scales: Lake Erie, Haldimand-Norfolk Region, and the Long Point area, because it is important to understand that Long Point is influenced by processes that may occur outside the local area. For example the glacial history of Lake Erie and regional patterns of weather, climate and storms are important in explaining basin wide changes and their influence on Long Point.

The factors leading to shoreline flooding and erosion hazards are complex and interrelated. An understanding of the dynamics of sediment transport is essential to understanding the location and frequency of shoreline flooding and erosion hazards. This involves identifying sediment sources and sinks and estimating sediment budgets for shoreline areas. However flooding and erosion should not be viewed only as hazards, rather they can be considered as essential natural processes within coastal and aquatic ecosystems. Flooding of low-lying beach and dune areas results in transport of sediment and nutrients into bay and marsh environments promoting vegetation succession, dune development and infilling of shallow inlets and channels. Sediment removed from shore bluffs, beaches or dunes by wave erosion is transported alongshore by wave and wind action and deposited to form beaches. Sediment is important for the establishment of beaches and dunes and for providing wildlife habitat, protection from future flooding and erosion, and for recreation and other human activities.

The natural processes of flooding and erosion are in turn greatly influenced by a variety of human activities. The use of shore protection structures, such as concrete walls (Photo # 1) and stone groynes can trap sediment transported alongshore by wave action resulting in loss of sediment further along the shoreline. Development of cottages (Photo # 2), marinas (Photo # 3), channels, and boat slips can also change the natural patterns of sediment movement. Buildings in low-lying shoreline areas are prone to flooding during periods of higher water levels. Continued dredging for sand and construction purposes alters shoreline and offshore surfaces can create increased potential for flooding. Only when human activities are allowed in areas prone to flooding and erosion (Photo # 4), is a hazard created. The magnitude of these hazards is often described in terms of damage to properties.

Property damages have increased sharply from flooding and erosion over the last four decades. The damages associated with high water levels in 1951/52, 1972/73 and 1985/86 are shown Table 1. These numbers suggest that government policies and programs have been ineffective in reducing losses from Lake Erie shoreline flooding and erosion.

Table 1. Lake Erie Shoreline Property Damage

	1951/52	1972/73	1985
Lake Erie Shore [1]	$89.2 million	$196.5 million	incomplete data
North Shore [1]	$3.3 million	$10.8 million	$26.3 million
Long Point region	$250,000 [2]	$1.0 million [3]	$10.1 million [4]

[1] from Kreutzwiser, 1977 and 1987
[2] estimated from newspaper articles and is for period 1954/55
[3] from Environment Canada/Ontario Ministry of Natural Resources, 1976
[4] from Haldimand-Norfolk Lakeshore Damage Survey, 1986

Photo # 1. Cottage on Hastings Drive

Photo # 2. Dunes and Cottages at Long Point

Photo # 3. Marina and Trailers at Booths Harbour

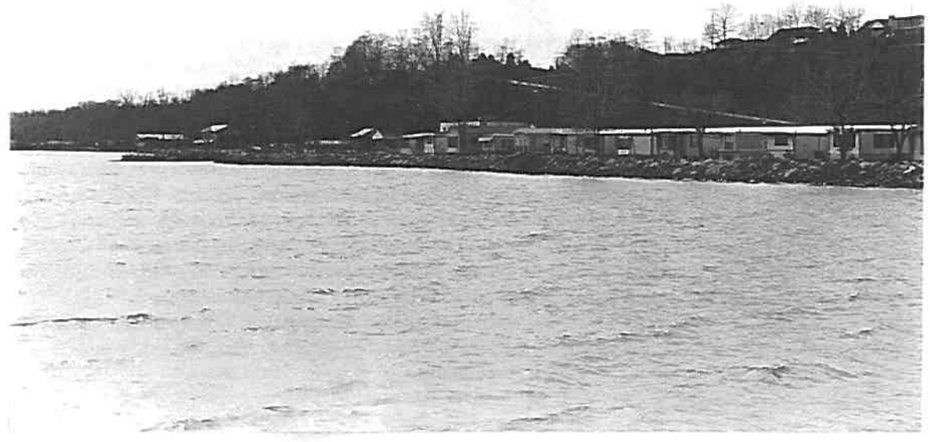
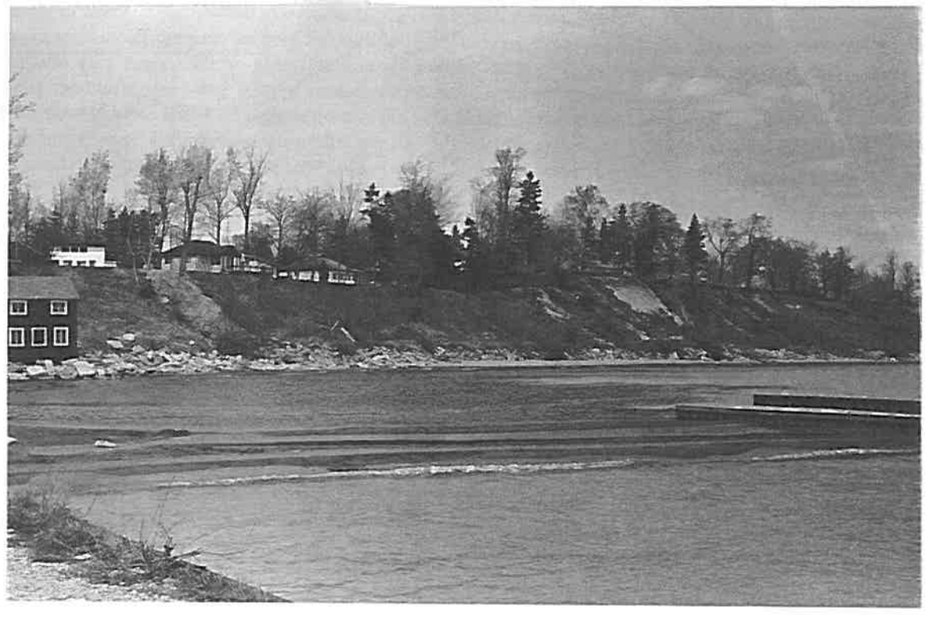


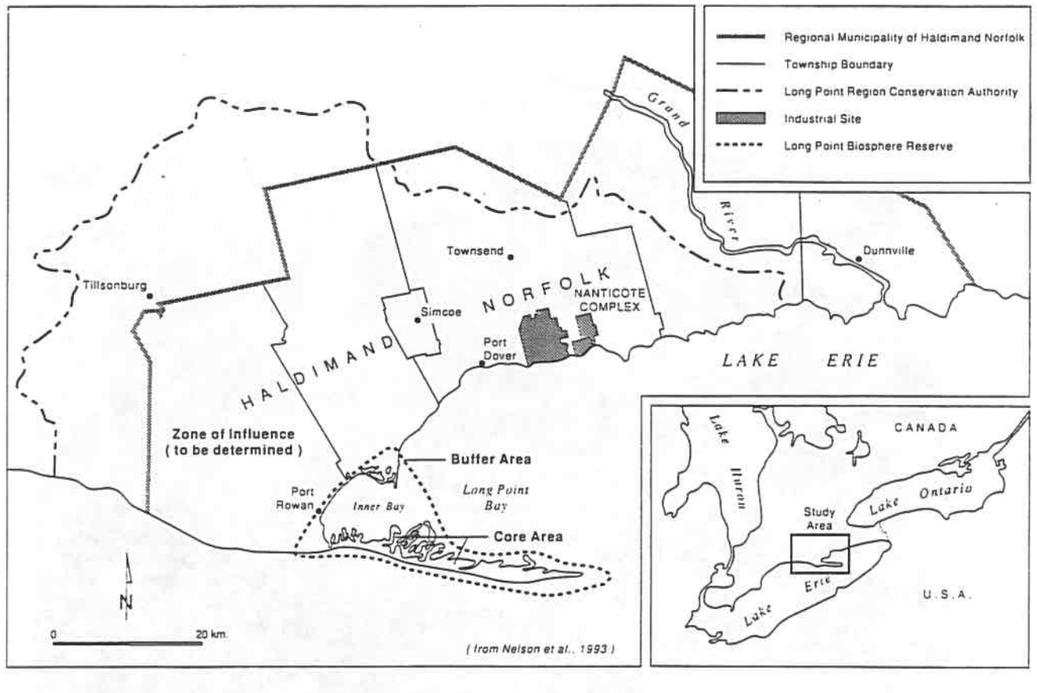
Photo # 4. Bluffs and Residences east of Normandale



It is important to note that government policies and other factors often operate to keep people in the same place and to protect existing interests by reinforcing the status quo. Development pressures, economic opportunities, insurance, government incentives, and land use planning often contribute to increasing hazards and damages by encouraging and supporting continued and increased occupance of known hazard zones. In Ontario, an example is the establishment of provincial grant programs for shoreline landowners during high lakes levels in 1972/73 and 1985/86 which provided for construction of structures to protect properties, such as breakwalls and groynes (Davidson-Arnott and Kreutzwiser, 1985; Kreutzwiser, 1987). Human response to hazards has also been crisis dominated. Concern and awareness of flooding and erosion on the Great Lakes rises and falls with the fluctuating water levels.

Shoreline flooding and erosion on Lake Erie have been identified as a major management issue in the Long Point area (Francis et al., 1985; Weller, 1989). The purpose of this report is to provide a summary of the development of shoreline flood and erosion hazards in the Long Point area. This study is completed as part of the preparation of an environmental folio for the Long Point Biosphere Reserve (Nelson et al., 1993). The goal of the folio is to provide information for decision-making by the local community and other agencies and groups concerned about the environmental health and economic well being of the area. The Long Point area was designated as a World Biosphere Reserve in 1986 and consists of a core protected area (Long Point National Wildlife Area), buffer area (defined by the 10 metre depth contour offshore and the regulatory 1:100 year flood line onshore) and a undefined zone of influence (Nelson et al., 1993) (Figure 1). The shoreline is characterized by: 30 to 40 metre high eroding clay bluffs to the west; the 40 kilometer long sandy spit environment of Long Point with its associated dune and wetland systems; and low-lying beaches, wetlands and bluffs to the east. The dune and wetland systems have an exceptionally rich mix of habitats consisting of an open lake, shallow bays, sand bars, beaches, dunes, forests and scrub, ponds, and marshes. The region is host to a variety of land use and resource conflicts and to many significant species and habitats.

Figure 1. Long Point Study Area



LAKE ERIE SHORELINE

Lake Erie (Figure 2) has a surface area of 25,700 km^2 with an average depth of 21 metres and maximum depth of 60 metres offshore of Long Point. The shoreline of Lake Erie is 1402 km long within a 78,000 km^2 drainage area supporting an approximate population of 13 million. The low-lying sedimentary character of much of the shore combined with the southwest-northeast orientation of the lake basin, regional climate, and human development have led to significant shoreline flooding and erosion. Shoreline flooding and erosion on Lake Erie are dependent on a number of factors including water level fluctuations, wind speed and direction, shoreline and offshore physiography, and sediment transport.

Lake Erie is subject to water level changes (Figure 3) due to long and short term variations in precipitation, basin runoff, and storm events. Extreme annual water levels of 1.5 to 2 metres from the mean have occurred in irregular cycles and are due to basin wide climate variations. For example, above average precipitation in the basin was recorded for 13 of 16 years between 1970 and 1985, while the rate of evaporation was lower then the long term average due to lower air temperatures (Yee and Cuthbert, 1985). The effect was to create a 12% increase in water supply to the lakes, resulting in higher water levels in 1985/86. Seasonal changes of 0.3 to 0.6 metres in mean monthly lake levels are the result of monthly variations in basin runoff and evaporation. Great Lakes water levels are characterized by peak high levels in June or early July following spring snowpack melt and spring precipitation, resulting in increased runoff into the basin. Storm surges, wind setup, and seiches can cause local increases in water level of up to 2 metres in a few hours (IJC, 1989). Wind setup is a local rise in water levels due to forced movement of the lake surface by prolonged high winds and may occur for only a few hours. A seiche is a more prolonged displacement of water which is controlled by the basin orientation and wind direction. Wind in the Lake Erie basin is characterized by prevailing and dominant southwest and west directions. The strongest winds are associated with the passage of weather depressions, and these are most frequent and intense in the spring and fall (Davidson-Arnott and Law, 1990). Persistent southwest winds can create wind setup conditions in the eastern basin of 1.0 to 1.75 metres as a result of wind speeds in excess of 50 mph (Gelinas and Quigley, 1973). Moderate onshore winds in the summer can also occur due to daily heating and cooling cycles. Wave action along the beach is limited from mid-December to March/April as a nearly continuous lake ice cover and shore ice foot develops on Lake Erie.

The Lake Erie shoreline consists of a variety of landform types (Figure 4). The type of shoreline strongly influences the frequency and magnitude of flooding and erosion. The clay till bluffs in the central portion of the north shore are prone to erosion from wave action and continued slope instability (Boyd, 1981). On Lake Erie a large amount of sediment is eroded from these bluffs and is transported alongshore by wave action and currents causing the formation of the peninsulas of Pelee, Rondeau and Long Point (Figure 5). These low-lying beach and dune areas are very susceptible to extensive inland flooding during higher water levels. Continued sediment supply from the bluffs and other sources is essential to the continued maintenance of beach and dunes at these sites. Wide sand beaches and dune complexes provide natural protection in the form of buffers from flooding and erosion during higher water levels (Saunders and Davidson-Arnott, 1990). Understanding the dynamics of alongshore sediment transport on Lake Erie is thus essential to understanding the distribution and frequency of flooding and erosion events at Long Point and other hazard areas.

The shoreline of Lake Erie is heavily developed, reflecting almost two hundred years of modern human settlement in the form of agriculture, industrialization and urban communities. For the recent IJC levels reference study (IJC, 1993), aerial photography was used to map land uses and it was estimated that developed lands (residential/industry) comprised 22% of the Canadian shoreline; agricultural/forest/open space, 63%; and recreational and natural areas, 15% (Figure 6). Generally, the central portion of the Canadian shoreline is predominately agricultural, with rural settlements, harbours and marinas located at river mouths and on the shore of the three sand peninsulas. These facilities provide economic and recreational opportunities such as cottages, fishing, and boating. The IJC study also indicated that future land use trends would include increased urban growth and expansion of residential (cottage) communities leading to loss of natural areas, notably forests and wetlands. The Great Lakes Shore Damage Survey estimated that the Lake Erie shoreline was divided among federal (5%), provincial (8%), municipal (6%), and private (81%) ownership, with total shore property values of $323 Million (Environment Canada/Ontario Ministry of Natural Resources, 1975).

Figure 2. Lake Erie Basin
(from Stenson, 1993)

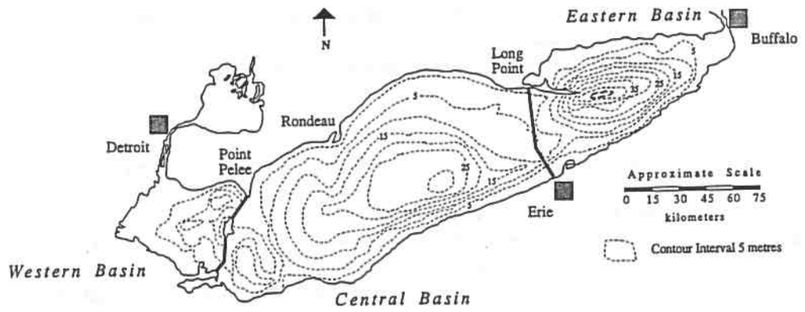
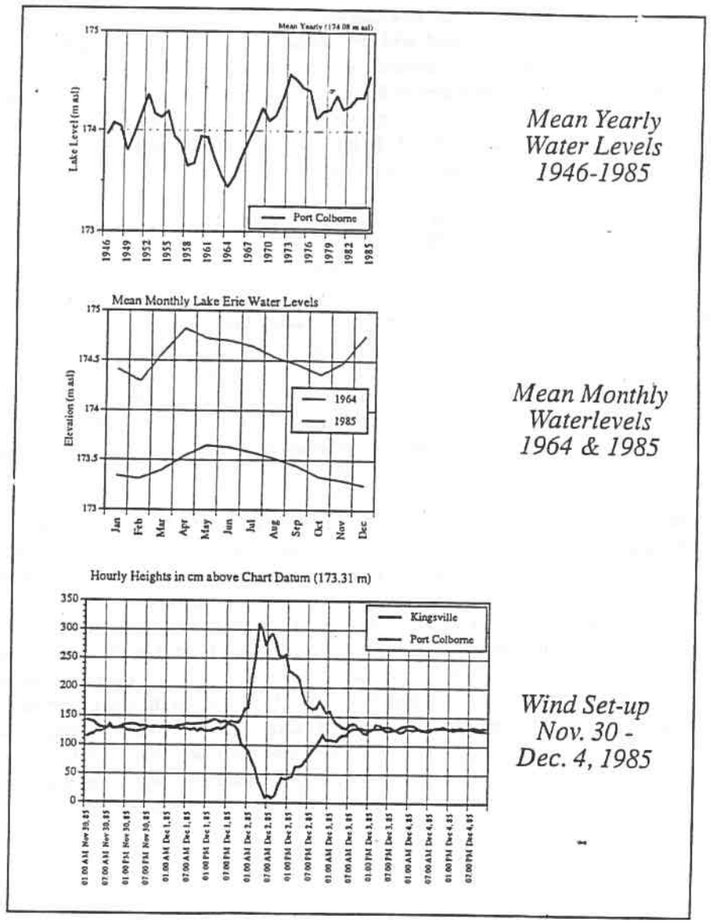


Figure 3. Lake Erie Water Levels



Mean Yearly Water Levels 1946-1985

Mean Monthly Waterlevels 1964 & 1985

Wind Set-up Nov. 30 - Dec. 4, 1985

Figure 4. Lake Erie Shoreline Types

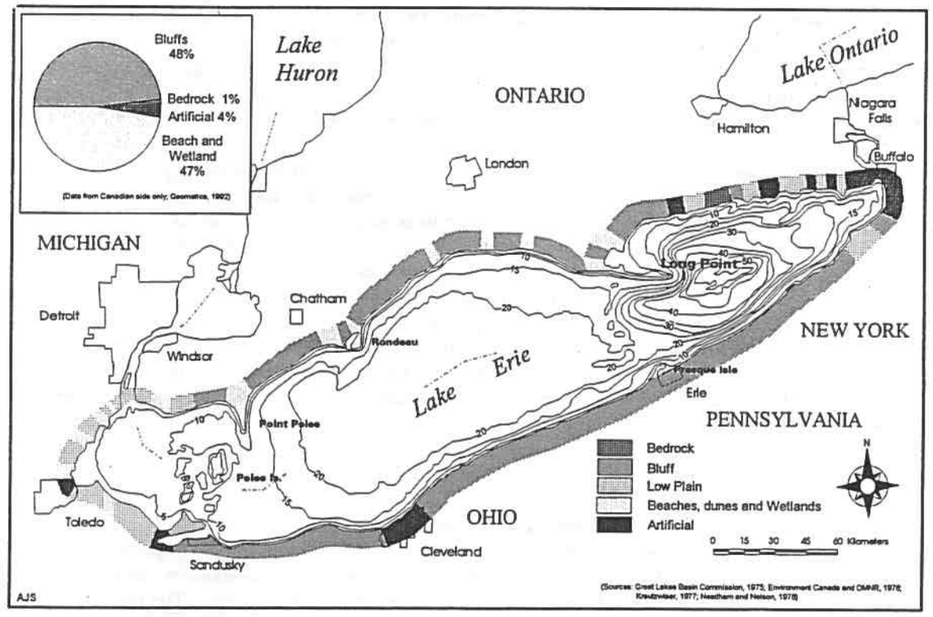
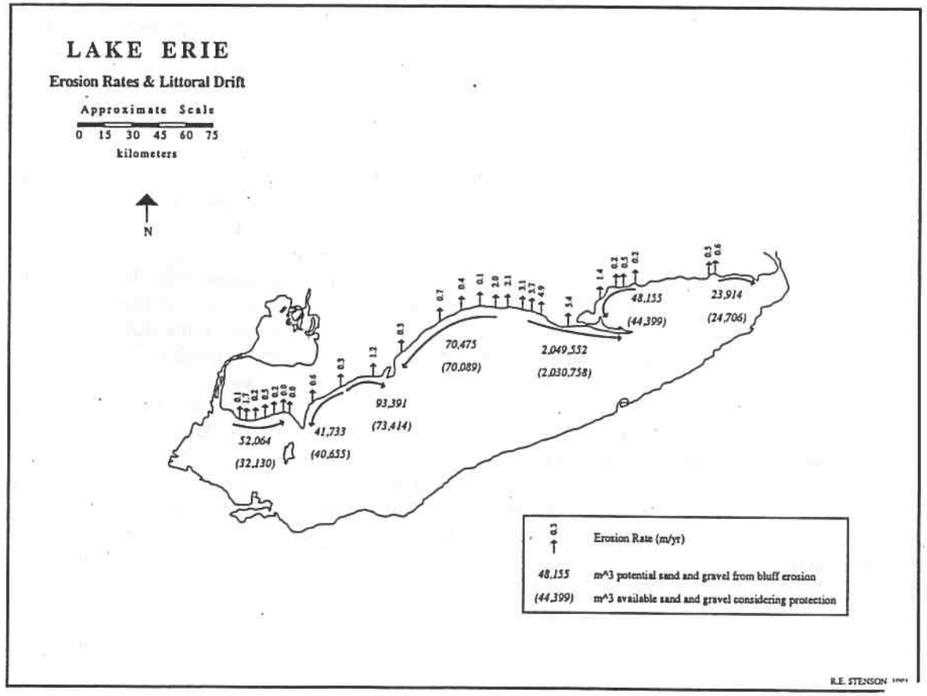


Figure 5. Lake Erie Erosion Rates and Littoral Drift



The combination of natural flooding and erosion processes with extensive land use and development leads to continuous hazards and associated damages and impacts (Figure 7). Low-lying topography, shallow lake basins, and effects of wind set-up and seiches can cause severe flooding at the western and eastern ends of the lake. The shoreline in the central basin is particularly vulnerable to nearshore, beach, and bluff erosion. Beach, dune and wetland areas, such as Long Point, are especially exposed to direct wave action and experience moderate to severe flooding on a continual basis. Over forty percent of the Lake Erie shoreline is prone to severe flooding or erosion (Environment Canada/Ontario Ministry of Natural Resources, 1975; IJC, 1989).

A variety of approaches have been used in attempts to reduce the costs of damages to property, roadways, and other losses from the hazards of flooding and erosion on the Great Lakes shoreline. In 1972 -73 federal and provincial governments expended in excess of $ 6 million in assistance to land owners (Kreutzwiser, 1987). The Ontario Shoreline Property Assistance Program provided 85 loans for Lake Erie properties in the period 1987-88 for a total expenditure of $789,900 or an average of $9292 per property (Ecologistics Ltd., 1992). Individual property owners and government agencies have preferred to use shoreline protection structures to attempt to control the hazard. A survey of over 8,000 shoreline riparians (IJC, 1990) suggested that 62% of all Lake Erie shoreline properties were protected and 20% had protection installed as a result of damages from high water levels in 1985-86. The common types of structures were seawalls or revetments, used by 72% of landowners, breakwaters (43%), groynes (27%), and dykes (13%): these numbers do not total 100% as landowners have used more then one type of structure. The Great Lakes Shore Damage Survey (Environment Canada/Ontario Ministry of Natural Resources, 1975) has estimated that the total value of private shore protection on Lake Erie was $227 million and there undoubtedly been a considerable increase since that time.

Provincial programs were developed following high water levels in 1985-86 (Ontario Shoreline Management Review Committee, 1986; Ontario Ministry of Natural Resources, 1987) in an attempt to reduce damages from flooding and erosion by establishing standardized shoreline development setbacks for land uses, emergency response programs, shoreline inventories, and preparing shoreline management plans. The use of municipal land use bylaw regulations to control shoreline development in flooding and erosion hazard areas is not yet consistently and assertively implemented. A 1988 study of 13 selected municipalities on Lake Erie indicated that an 34% increase had occurred in development in shoreline hazard zones. Only 6 of the municipalities had 1:100 year flood elevations and 11 had setbacks ranging from 15 to 150 metres (Kreutzwiser, 1988). Shoreline municipalities have developed a wide range of zoning classifications to control and regulate land uses; however, large numbers of these municipalities have no defined flood or erosion areas with setbacks in their official plan or secondary land use bylaw documentation. Amendments and exceptions to existing setbacks are also frequent.

REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

The Lake Erie shoreline of the Regional Municipality of Haldimand-Norfolk (RMHN) extends from east of Port Burwell to Dunnville at the mouth of the Grand River (Figure 8). The Haldimand-Norfolk shoreline land uses consist of: undeveloped (beaches/wetlands) (38%), development (residential/industrial/commercial) (25%), agricultural (24%), open water (4%), recreation (parkland) (2 %) (IJC, 1993). The IJC study also suggests that future trends would include a 23% decrease in agricultural lands with increases in residential development. The number of residential dwellings in the RMHN lakeshore has been estimated at almost 5000 (Warner, 1988). The total shore property values are approximately $25 million and shore protection cost has been estimated at $64 million (IJC, 1993). A sample of lakeshore or lakeview properties listed for sale on the real estate multi-listing service in February 1993 indicated 35, with a total value of $3.7 million (average $106,000).

The shoreline can be divided into two main sections: the sand plain including the Long Point spit, and the clay plain to the east. This shoreline consists predominately of beach and dunes (39%) high bluffs (24%) low bluffs (17%), wetlands (16%), artificial (3%), and bedrock (1%) landforms (Geomatics Ltd., 1992). Five separate shoreline reaches can be identified: 1. the high eroding clay and sand bluffs on the exposed north-central Lake Erie shoreline, 2. the dune and wetland complex of Long Point extending 40 kilometers into the lake, 3. the sheltered wetland and low bluff shoreline of the Inner Bay, 4. the narrow beaches and transition into low clay bluffs from Turkey Point to Port Dover, and 5. the low lying, irregular, clay plain and bedrock shoreline east to Dunnville.

Figure 6. Lake Erie Shoreline Land Uses

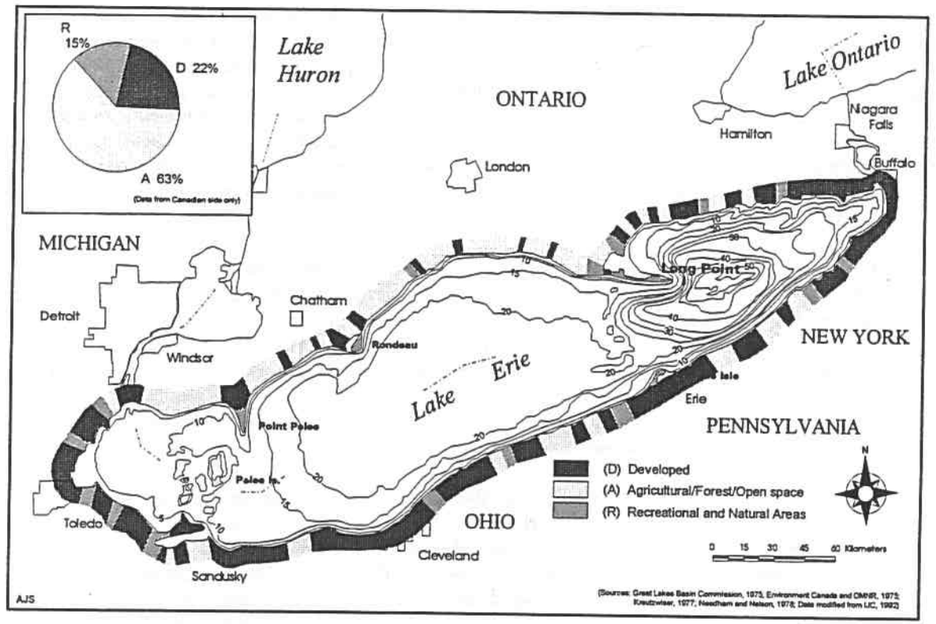
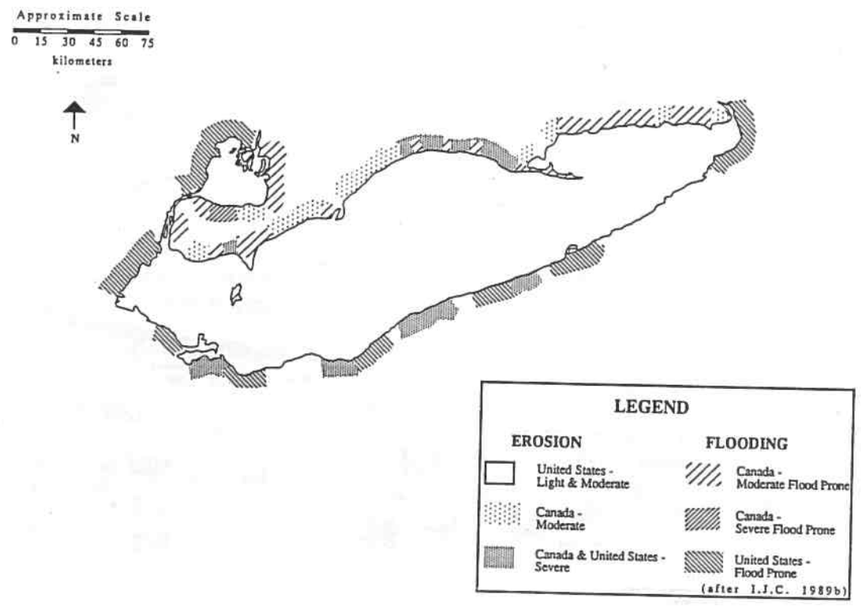


Figure 7. Lake Erie Flood and Erosion Prone Areas



Sediment eroded from shoreline bluffs, or deposited on beaches and offshore by streams and rivers, is moved from the west to east along the north-central shoreline of Lake Erie by wind, waves, and currents (Boyd, 1981; Reinders, 1988). The majority of the sediment is then deposited by wave action along Long Point, as the peninsula acts as a barrier to continued eastward transport. The Inner Bay and areas to the east are protected from southwest winds, however, they are under the influence of easterly winds and waves resulting in transport towards Turkey Point. Limited sources of sediment in the eastern half of the region reduce alongshore sediment transport and subsequent beach and dune development. Big Creek is the major source of sediment into the Inner Bay (Ongley, 1976; Reinders Ltd., 1988; Philpott Ltd., 1989), but due to discharge into Big Creek marsh and a poor understanding of the dynamics of currents and water exchange between the marsh, Inner Bay and Outer Bay, the ultimate deposition of this material is unclear. Small amounts of sediment are also supplied from streams, gullies, offshore erosion, and human activities (e.g. dredging, channelization).

Development along the Lake Erie shoreline has historically occurred in shoreline flood and erosion prone areas. Jessen and Day (1980) indicate that during a three year sample period from 1975 to 1977, 1/3 of the 71 lakeshore development applications submitted for regional government approval were considered to fall into the dynamic beach area and 50% were inside of the 1:100 year regulatory flood line. The majority of these applications were for extension to existing cottages (30%) or accessory buildings (30%), e.g. sheds, garages, or boathouses. In addition 30% were for new construction of permanent or seasonal residences. Development has continued in the communities of Long Point and Turkey Point, notably in the form of marina construction and conversion of seasonal (cottage) residences to permanent residential units.

Due its topography and exposure to wave action, the shoreline is highly susceptible to severe flooding and erosion (Figure 9). Major storm events in 1954 (Hurricane Hazel), 1955, 1973, and 1985/86 were particularly destructive. During high water levels in 1972-73 total damage in RMHN exceeded $ 1 million or $4638 per km (Environment Canada/Ontario Ministry of Natural Resources, 1975). The Haldimand Lakeshore Damage Survey (1986) estimated 10 million dollars worth of actual damage from the December 2nd, 1985 storm alone. Areas of concern include beach erosion and flooding along the lakeside of Long Point with frequent washover and dune breaching, inland flooding of marsh and wetland areas in the Inner Bay and Turkey Point, flooding at the main beach area of Port Dover, and beach erosion and flooding in the Townships of Haldimand and Dunnville.

Figure 8. Haldimand-Norfolk Region Shoreline

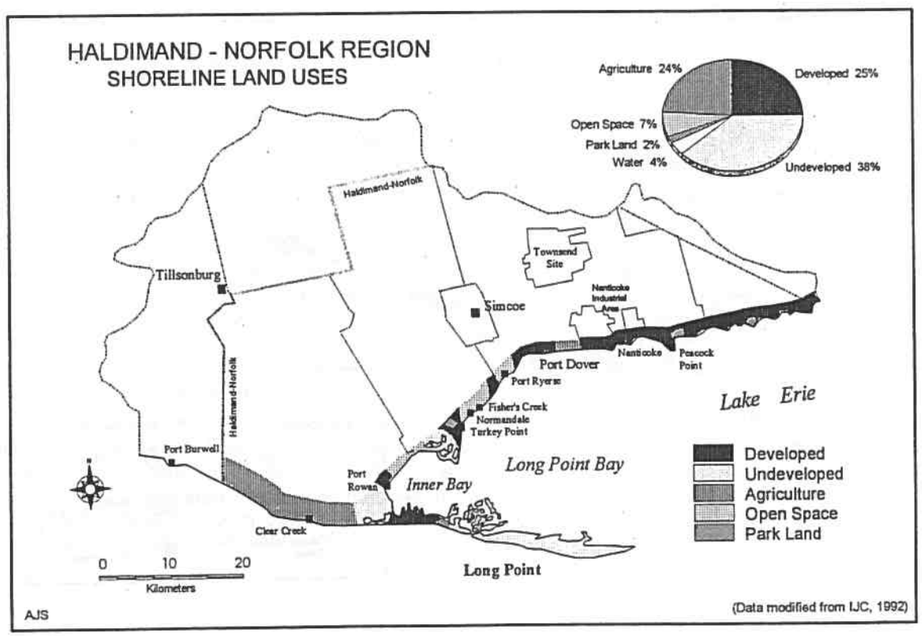
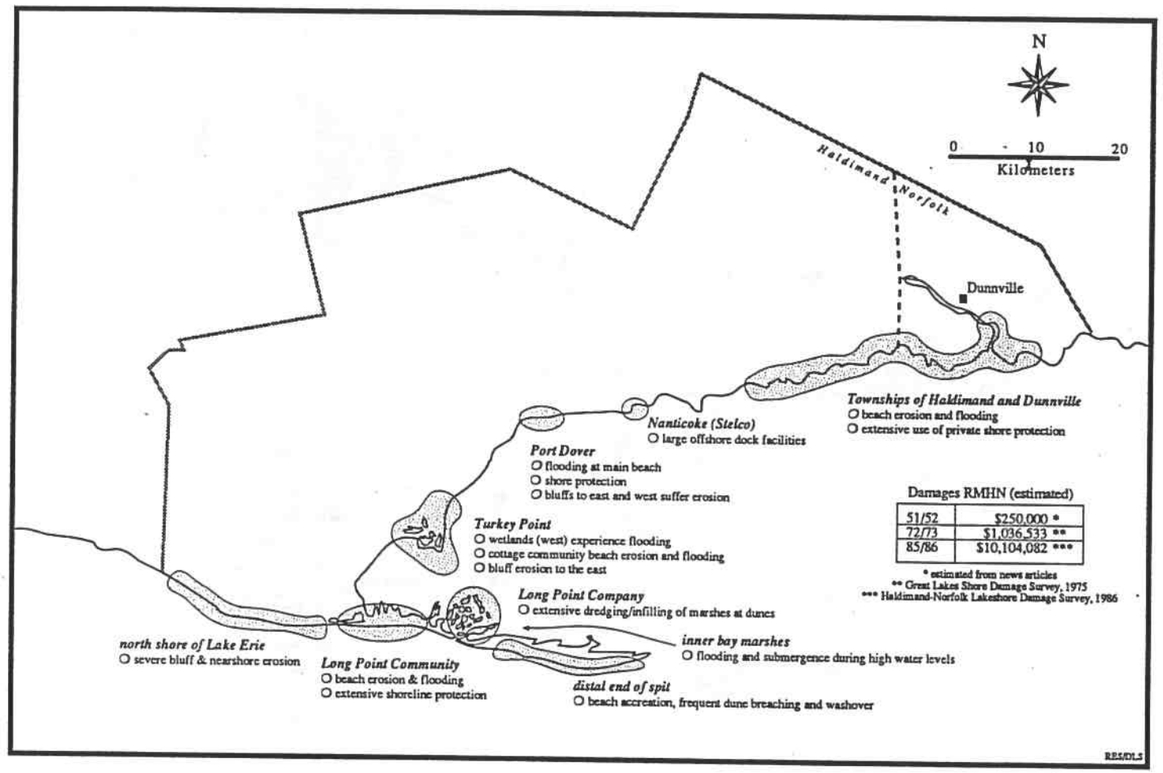


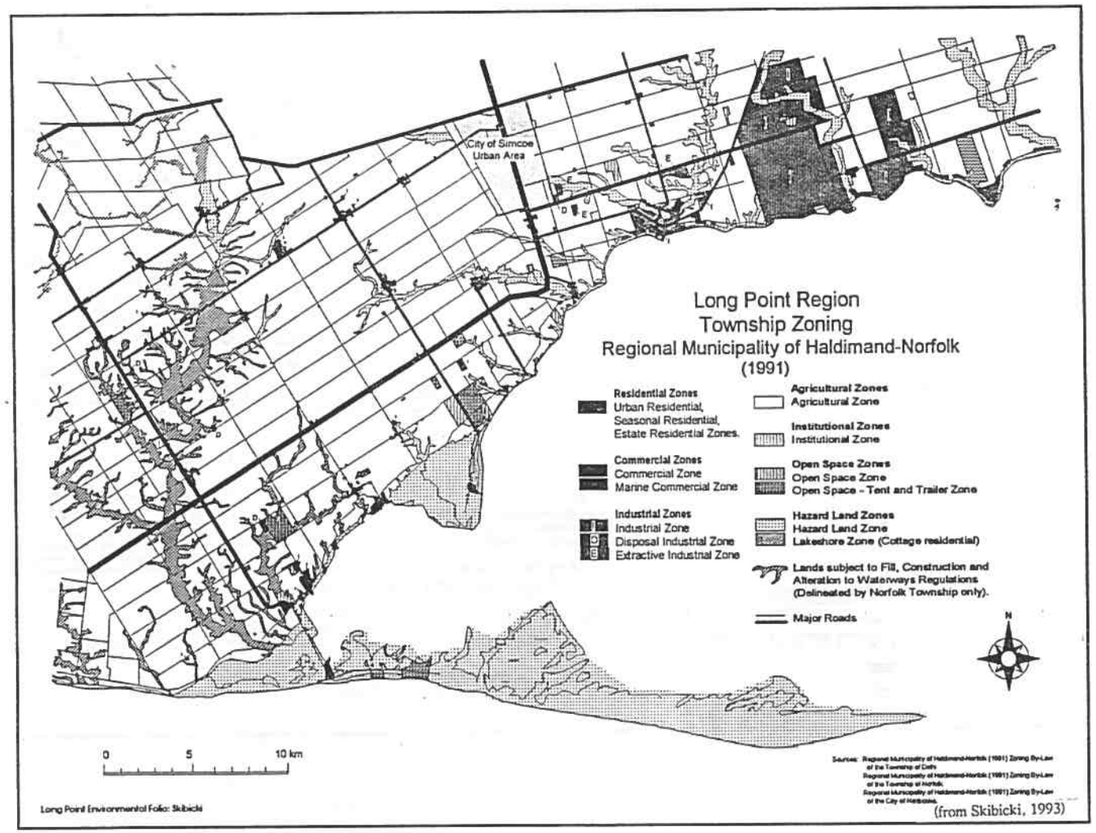
Figure 9. Flooding and Erosion Hazards: Areas of Concern



It has been estimated that 8% of this shoreline has been protected by some type of structure (Environment Canada/Ontario Ministry of Natural Resources, 1975). Shore protection is primarily focused around the major communities of Long Point, Turkey Point, Point Dover, and the Nanticoke-Featherstone shoreline. The types of shore protection structures include: revetments, used by 40% of landowners, seawalls (45%), groynes (12%), jetties (3%) and breakwaters (3%) (Philpott Ltd., 1989). Fraser et al. (1977) estimated average expenditures of $4,097 including some house raising and house moving costs in the Long Point to Port Dover area. The Ontario Shoreline Property Assistance Program (1987-88) issued 20 loans to residents in Haldimand-Norfolk, with a total expenditure of $241,800 for an average of $12,000 (Ecologistics Ltd., 1992).

The majority of the RMHN Lake Erie shoreline is designated by local municipalities as Hazard Zone (Figure 10) which restricts land use types and provides setbacks for flooding and erosion to protect buildings and septic systems. Major exceptions to this policy include the Lakeshore Zone, allowing cottage residential development at Long Point and Turkey Point; agricultural zoning along the north shore between Turkey Point and Port Dover, and industrial zoning at Nanticoke. As has been suggested by several authors (Jessen and Day, 1980; Warner, 1988) the main problem is continued new development or renovations of residential buildings at the communities of Long Point and Turkey Point. These areas are prone to frequent flooding resulting in property damage and water pollution from private septic systems.

Figure 10. Haldimand-Norfolk Region Lake Erie Shoreline Land Use Zoning (from Skibicki, 1993)



(from Skibicki, 1993)

LONG POINT

Long Point is a sand spit formation extending forty kilometers into Lake Erie and consists of a series of recurve dunes separated by wetland/marsh slacks. The lakeside shore is characterized by wide sandy beaches backed by dunes, while the bayside is made up off small inlets and marshes (Figure 11). Long Point represents a sink for sediment transported along the north shore of Lake Erie, over a distance of 85 kilometres from the west. The majority (89%) of sediment is supplied from erosion of bluffs (Port Burwell to Clear Creek) with additional supply from streams/creeks, gully erosion, and nearshore erosion (Rukavina and Zeman, 1987). Mean annual sediment transport to Long Point has been estimated from 62,000 to 200,000 m^3/year (Philpott Ltd., 1989). The majority of this sediment is deposited along the spit at distal, or far end of the point (Figure 12). The spit is presently extending at the tip into the lake at about 5 metres per year, building a platform into water depths of 60 metres (Coakley, 1983; Rukavina and Zeman, 1987).

Nearshore sediment transport along the bayside of the spit is controlled by the magnitude and frequency of east and northeast waves entering the bay. Approximately 46,000 m^3/year of sediment is transported from east-west and is deposited along Turkey Point and in Long Point Inner Bay (Figure 12). Large waves can be generated from the east-northeast, with a fetch of over 100 km, propagating into Long Point Bay. However, because of the deep water at the end of the spit there is very little refraction of the predominant southwest waves around the point and they effect only the last few kilometers of the end of the bayside of the spit.

Sediment dynamics within the Inner Bay are not well understood. The presence of the Long Point spit and a submerged offshore bar between Turkey Point and Long Point creates a barrier to significant current and wave activity. This situation creates a somewhat protected sheltered Inner Bay environment. Sediment transport alongshore, and from offshore sources, into the Inner Bay is therefore limited. Big Creek has an estimated mean annual discharge of 7.0 m^3 per second carrying 77,000 tons of solids, with peak flows from January to April (Ongley, 1976). Since measurements are conducted near the mouth of Big Creek, the exact amount of sediment transported into the bay is not known. However, Big Creek seems to be the only major source for sediments into the Inner Bay.

On the lakeside the spit can be divided into three units. The proximal zone is located from the base of the spit east to the Long Point Company property and is characterized by steep nearshore profiles, narrow beaches, one or two foredunes, extensive overwash activity and small inlets (Davidson-Arnott and Fisher, 1992). In this area cottage development and associated erosion has resulted in the loss of all the original dunes (Saunders and Davidson-Arnott, 1990). The central zone consists of old dunes currently being eroded by wave action. The distal zone, or far end, is up to 3 km in width and is the site of active beach growth and the formation of new dune sequences (Davidson-Arnott, 1988). The proximal and central zones have negative or near neutral sediment budgets, leading to overwash activity, inlet formation, and gradual transfer of sediment over the marsh and into the Inner Bay (Stewart and Davidson-Arnott, 1988). The sediment budget for the 10 to 12 km long distal end of the spit is positive and a sequence of dune ridges and intervening dune slacks over 3 kilometers wide has developed (Davidson-Arnott and Law, 1990)

Long Point has a long and rich human history and heritage with early native Indian settlements and the first European community two hundred years ago. The spit has long been treasured for its natural resources such as timber, fish, and wildlife. The Long Point Company, which purchased the majority of the spit in 1866 has practiced conservation and stewardship practices in order to conserve waterfowl for hunting. Extensive logging of the spit and removal of forest cover on the mainland to clear the land for agriculture progressed rapidly. Important land use milestone dates include settlement on the spit in the early 1800's, establishment of Long Point Park in 1921, construction of the causeway creating a permanent fixed link to the mainland (1929), and designation of the Big Creek (1973) and Long Point National Wildlife Areas (1979).

The present land ownership (Figure 13) reflects the diversity of human uses and attempts to preserve natural areas for waterfowl and wildlife habitat. Current shoreline land uses in the Long Point study area are: open water (41%), wetlands/beaches (33%), residential development (13%), open space/barren land, including agricultural land (10%), parkland (2%), and forest (1%) with public ownership quite high (62% of land area). Future anticipated land use trends are an increase in rural development including cottages and marinas, and reductions in forest and marsh/wetland areas (IJC, 1993).

The number of dwellings at Long Point community increased from approximately 50 in 1940 to 900 by 1990 (Warner, 1988; RMHN data). Currently 85 % of dwellings at Long Point are cottage or seasonal residential units (data provided by Mary Elder, RMHN) (Table 2). Over 1/2 of the cottages at Long Point are first tier and are located directly on the Lake Erie or Inner Bay shoreline. They therefore are exposed to beach erosion and flooding during higher water level events. Permanent residences at Long Point have also increased greatly in the last twenty years, from 50 in 1970 to 114 in 1992. These trends have resulted in increased real estate value and infrastructure investment in the Long Point community thus creating greater potential damages during future hazard events.

Figure 11. Long Point Shoreline

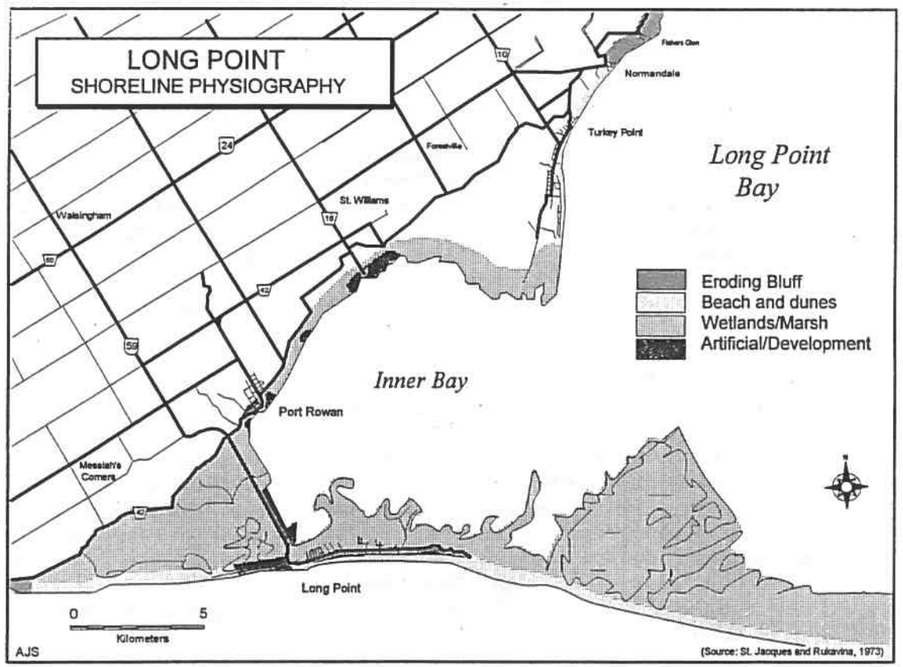


Figure 12. Littoral Sediment Movement and Sediment Sections in the Long Point and Turkey Point Area (from Stenson, 1993)

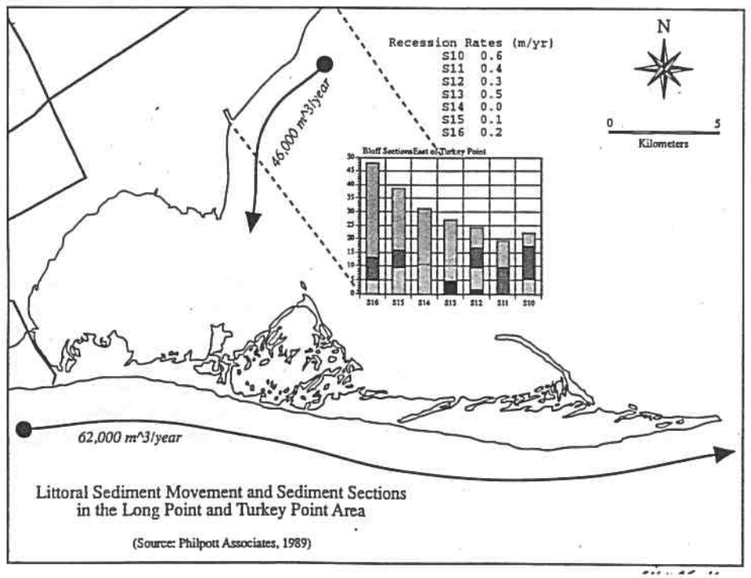


Figure 13. Long Point Land Ownership

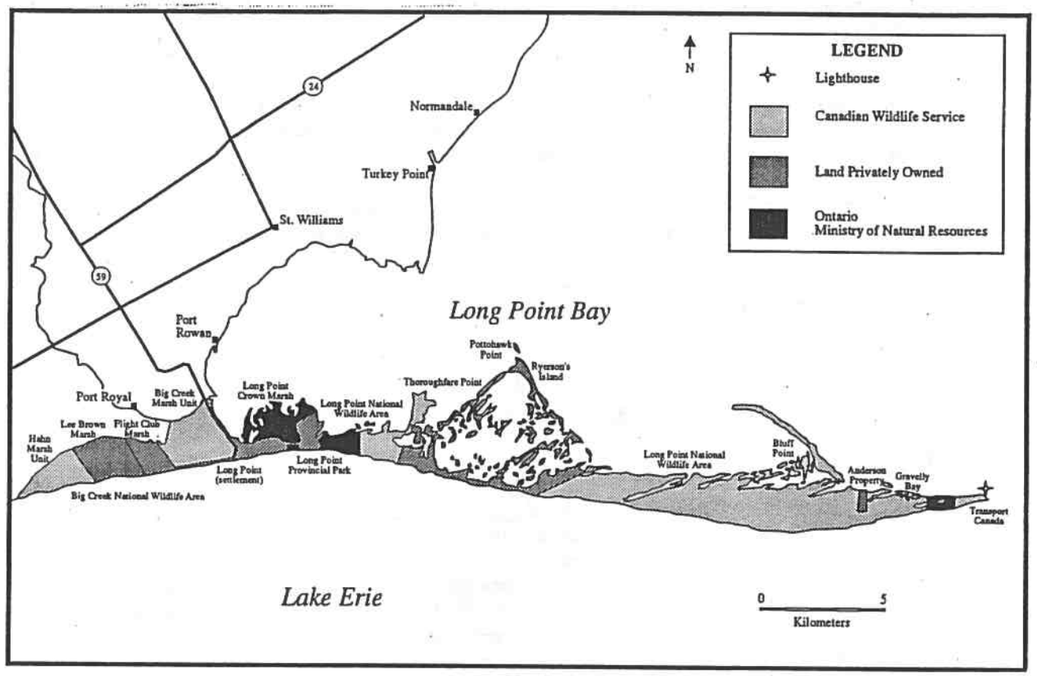


Table 2. Cottage versus Permanent Residential Development

Type	Turkey Point	Long Point	Port Rowan	Lakeshore
cottage	521	632	0	24
1st tier	194	391	0	10
2nd tier	327	241	0	14
Permanent	160	114	287	111
single family	155	97	243	109
farm	0	7	0	0
retail	5	10	27	2
multi-residence	0	0	17	0
Total	681	746	287	135
% cottage	76.5	84.7	0	17.7

(data provided by Ontario Ministry of Finance, Ontario Assessment System, 1992 and RMHN)

A survey was conducted of Long Point residents in 1988 (Rasid et al., 1992). The 112 respondents had an average length of residence of 20 years and 74% had owned their property prior to 1973-74. Development at Long Point and Turkey Point has consisted of a rapid increase in seasonal (cottages) residences over the last fifty years with recreational amenities, roadway improvements and relatively low rural values attracting land owners (Figure 14). In more recent years continued conversion of existing seasonal residences to permanent residences has occurred in areas prone to flooding and erosion and resulted in concerns for water supply, waste treatment, public access, and roads. In addition, development in the form of marinas, with channels, trailers and boathouses has increased to the extent that it covers the majority of the north shore of the Inner Bay with an current estimate of 13 marina facilities with 2800 boat slips, and 1500 trailer and campsites.

The Long Point area has experienced a series of severe storm activities leading to shoreline flooding and erosion and associated damages (Table 3). Large sections of the Inner Bay shoreline are flood prone while severe to moderate beach erosion has been identified along the entire shoreline (Figure 15). Residents have indicated that 81 % experienced flood damage and 62 % experienced shoreline/beach erosion during their residence at the location (Rasid et al., 1992). Long Point has historically been breached and separated from the mainland on numerous occasions. The low-lying topography, shallow offshore and exposure to wind and wave action make the lakeside of the spit particularly vulnerable. After rapid cottage development, beginning in the 1930's and 1940's, storms in 1954 and 1955 brought extensive property damages (Table 3). During high water levels in 1972-73 damages totaled $340,820 (Environment Canada/Ontario Ministry of Natural Resources, 1975). Fraser et al. (1977) estimated average water damage during 1972/73 storms and high water levels was $1,284. 34% properties had house and contents damaged.

Winds of up to 100 km per hour raised water levels at Lake Erie's eastern end by about 2.5 metres in a matter of hours on the morning of December 2, 1986 (Rasid et al., 1992). Southwest winds gusting up to 100 km/hour caused flood levels to peak in mid morning with a rise of 2.4 metres in standing water level, which was already almost one metre above the long average. On Long Point many cottages on Hastings Drive were demolished with several being swept into the Big Creek marsh (Yee and Cuthbert, 1985). Over $200,000 in municipal damage costs in Township of Norfolk were estimated from this storm (RMHN Lakeshore Damage Survey, 1986). At Long Point Provincial Park the 1985-86 high water levels resulted in beach and dune erosion, flooding in low lying areas and a 50% loss of beach area (Cain, 1988). Impacts included damages to roadways and infrastructure (buildings, water and electrical supply), closure of 45 campsites with estimated loss of revenue of $23,000, and estimated annual costs of 2-5% of the annual park budget on erosion damage clean-up and repair with additional estimated costs in 1986 of $10,000 to relocate water supply lines (Cain, 1988).

In response to the hazard, government agencies and land owners have used shore protection structures in an attempt to reduce the damages to property at Long Point. Since 1969, the percentage of shoreline length with protection structures has increased from 5 % to 36% (Figures 16 to 18). Seawalls (45% of structures) and revetments (40%) are the most common types used by property owners. Rasid et al. (1992) note that a total 79 % of current residents have taken protection measures with 1/4 raising their homes to prevent flooding and 1/2 have installed shore protection structures. The most extensive use of shoreline protection in the area is within the community of Long Point, from Hastings Drive eastward to the Long Point Provincial Park, where structures exist along approximately 80% of the shoreline. The Ontario Ministry of Transportation (MTC) distributed a total of 9,930 sandbags in 1973/74 at a total cost of $6,200. Additional protection was required for 600 feet of shoreline east of a gabion breakwall constructed by MTC in 1973 to protect the Highway 59 causeway. Increased downdrift erosion led to sandbag walls in 1974. The MTC spent a total of $177,00 and $210,00 under the Special Emergency Assistance Program from 1973-76 to maintain roads and services in Long Point and Turkey Point.

Figure 14. Cottage and Marina Development 1945 to 1990 and future trends

(determined by interpretation of aerial photographs, P. Lawrence)

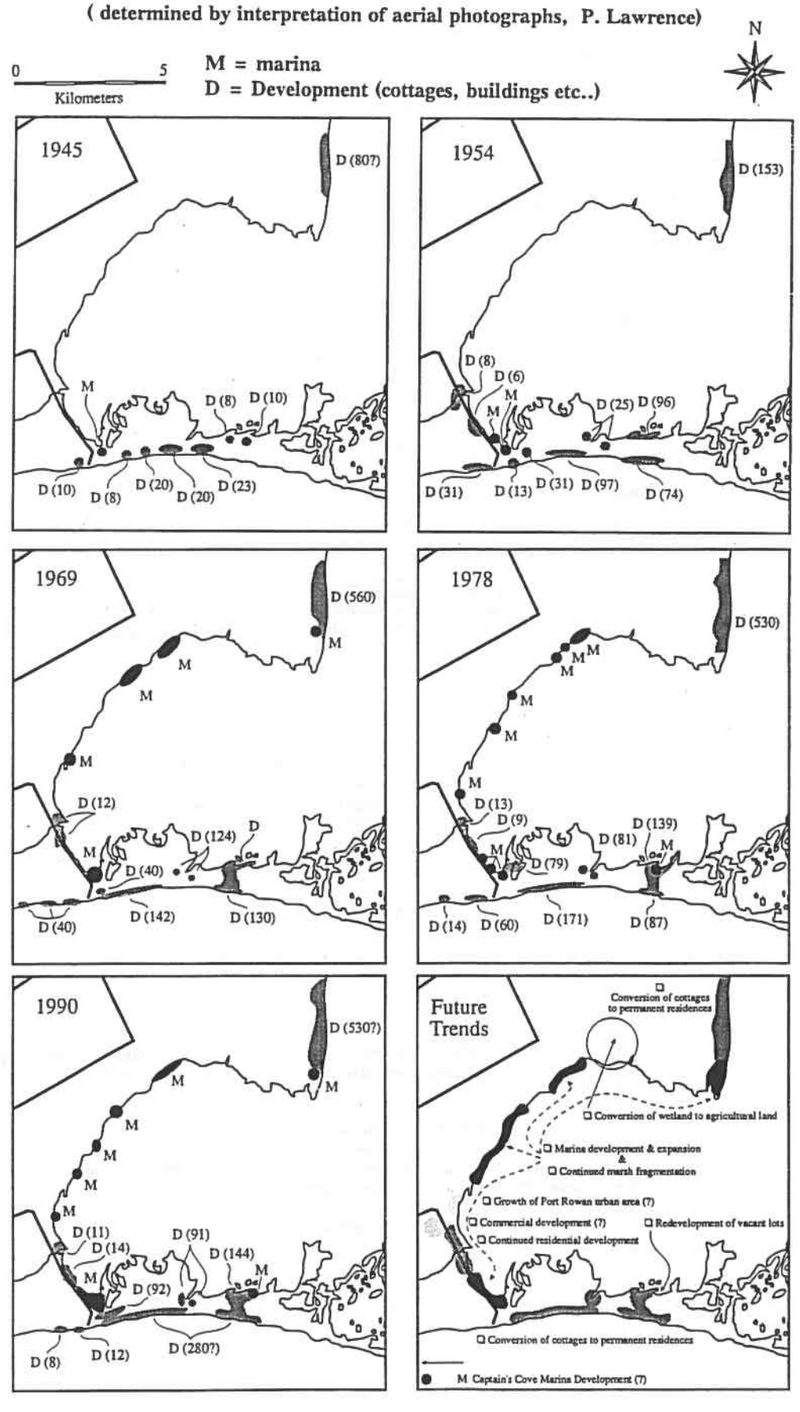


Table 3. Shoreline Hazards: Events, Damages and Adaptation in the Long Point Study Area

1883:	Long Point breached by storm, pier built to maintain channel at cost of $3,000 to federal government (`Old Cut').
1885:	Severe storm causing damage to existing pier.
1893:	Port Rowan pier built at cost of $8,413 (federal government).
1895:	Channel closed by deposition.
1901:	Channel reopened by storm.
1906:	Channel again closed by storm.
1911-13:	Port Rowan pier reconstructed ($8,000) and St. Williams wharf built ($2,511) by federal government.
1952:	Major storm destroys many cottages on Long Point.
Oct 1954:	Hurricane Hazel
Mar 1955:	Damage to cottages at Turkey Point and Long Point; ` several cottages were shattered by a pounding surf, some of them completely disappearing....wind whipped waves for 18 hours as gusts of 87 miles per hour `; `Storm wreckage at Long Point worse then hurricane havoc `; 80 cottages damaged, 5 deaths; ` hundreds of thousands of dollars[of damages] `(HSp 24-26 March/55); 70 cottages damaged at Hastings Drive, $1,000,000? (LFP 23 March/55).
1958:	Long Point cottages damaged by storm.
1969:	Repairs to Hastings Drive due to flooding damage, 18 inches of water over road. (BEx 25/July/69)
Jan 1971:	Storm causes damage to cottages at Long Point.
1973:	William Knowles (MP-Haldimand-Norfolk) suggested that the federal government should subsidize cottage owners near Long Point, many of them Americans, to help them move their homes away from Lake Erie...900 cottages at cost of $12,000 each...50 in ` imminent danger ` (LFP 11-13/Mar/73), shore protection built along Highway 59 causeway at cost of $177,253 (100% provincial funding).
Apr 1973:	20 acres of Long Point Provincial Park under 1 foot of water (KWR 19/Apr/73).
1973-74:	Township roads protected with stone ($118,000) 80% provincial funding.
Nov 1975:	Storm resulting in 4 foot lake level rise, flooding and beach erosion at Port Dover, Turkey Point, Port Maitland, and Long Point. ` 200 cottages flooded at Turkey Point ` (LFP 11/Nov/75). ` $200,000 damage at Long Point ..two cottages destroyed..20..3 removed from Hastings Drive...' 2nd storm in two weeks to cause extensive damage along Hastings Drive once considered one of the safest places for cottages'...province several years ago put in wood pilings ....owners added gabions ` (BEx 11/Nov/75). ` within 1/2 hour of evening water rose 8 feet, flooding 2 feet over causeway'.. damage at Turkey Point, Haldimand, Long Point Company...$500,000 damage (BEx 12/Nov/75).
1978:	Installation of a series of eight timber groynes at tip of Long Point to protection lighthouse and keepers cottage. Beach erosion continued at the site leading to destruction of the groynes in 1983.
1985:	Lighthouse keepers house removed due to shore storm induced flooding and beach erosion.
Apr 1985:	Severe damage to cottages along Hastings Drive due to wind and waves. Flooding across the roadway. Several cottages completely destroyed.
Dec 1985:	40 cottages destroyed at Long Point (KWR 12/Sept/86); 16 cottages destroyed along Hastings Drive (HSp 21/Nov/86); 50 properties at Long Point abandoned since storm, taxes reduced by an average $300 each for 60 homes and cottages at Long Point (TS 9/Mar/87).
Jan 1987:	Long Point Company plans construction of 2 1/2 mile long dike to run parallel to Lake Erie shoreline on southern end of property. Intention is to provide protection of marsh nesting grounds from flooding and overwash sediment occurring from recent storm activity. Located 600 feet from the waters edge, seven feet high using sediments dredged from marshes. Estimated cost of $250,000.
Jun 1987:	Long Point cottage owners win $30,000 insurance judgment as wind not wind-driven water knocked cottage off foundation (HSp 1/June/87)

Sources: Kreutzwiser, 1977: Needham and Nelson, 1978; Fraser et al., 1977
Brantford Expositor (BEx), Hamilton Spectator (Hsp), London Free Press (LFP), Toronto Star (TS)

Figure 15. Areas of Flooding and Erosion Hazards

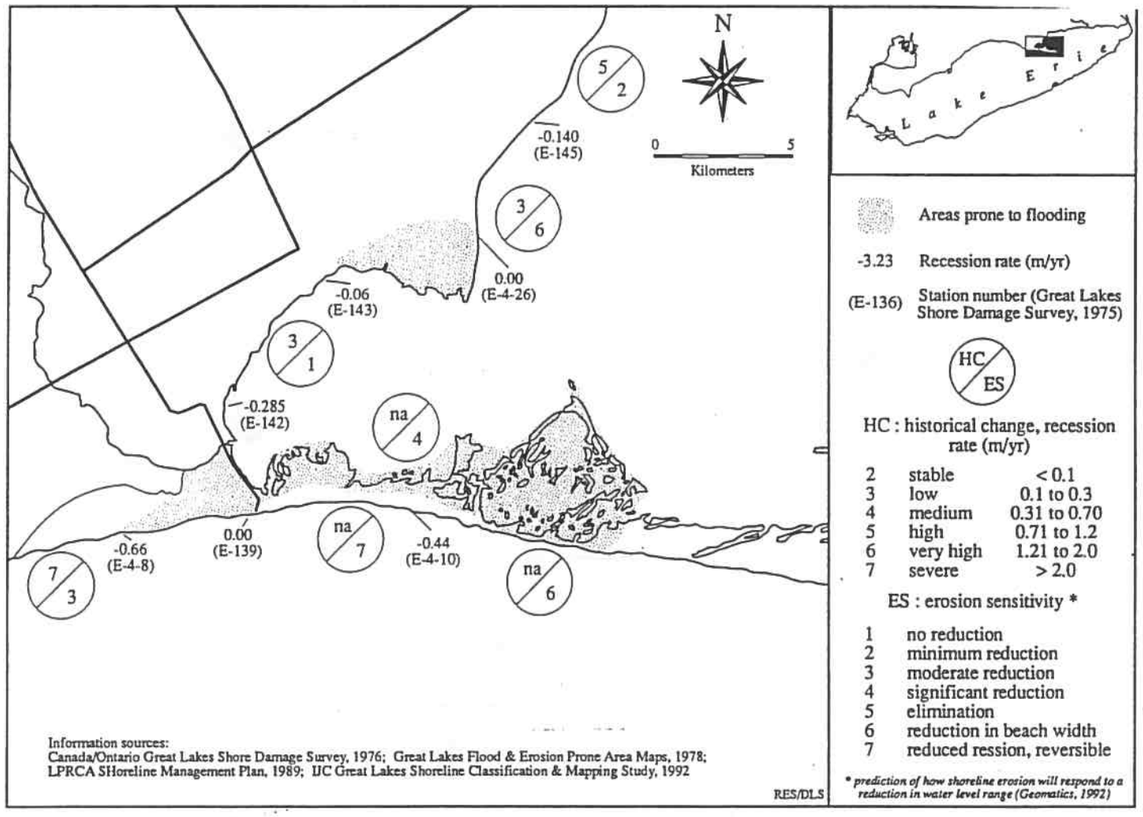


Figure 16. Shoreline Land Use, Hazards and Adjustments, 1969

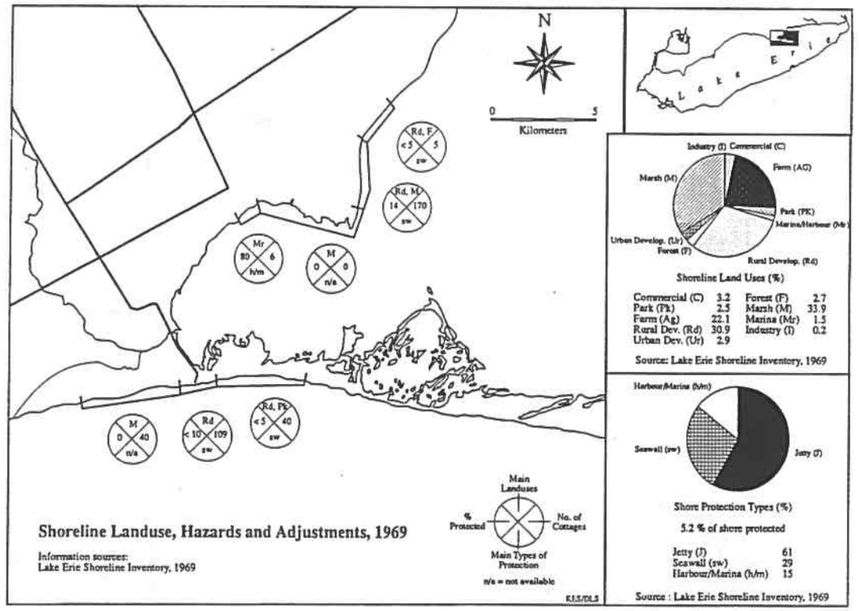


Figure 17. Shoreline Land Use, Hazards and Adjustments, 1976

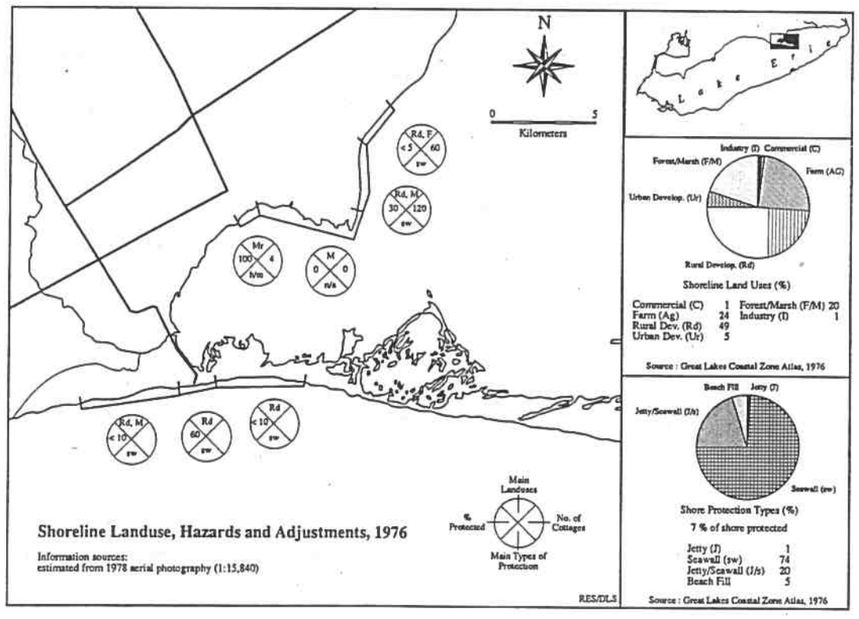
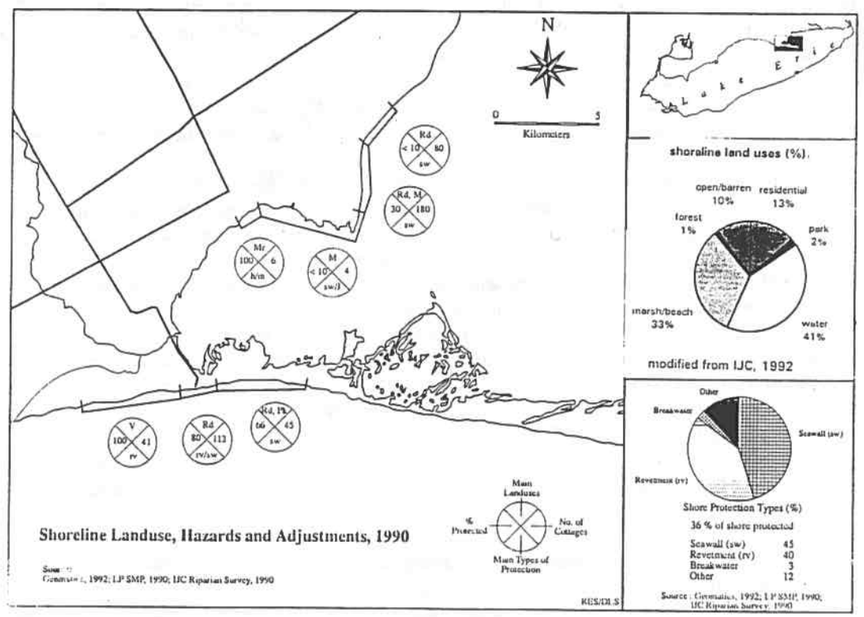


Figure 18. Shoreline Land Use, Hazards and Adjustments, 1990



Government policy development has been slow to respond and inconsistent in application of shoreline management and planning in the Long Point study area (Table 4). In response to high water levels and severe flooding and erosion the newly formed regional government (1975) adopted a series of policies and programs which attempted to control rapid residential development in hazard prone areas along the lakeshore. The Official Lakeshore Policy (1976) had recommended that all lakeshore development be stopped until pollution and continuing water quality problems associated with septic systems and other facilities were resolved. During the 1970's, inland flooding and high groundwater tables resulted in increased bacterial contamination of water due to seepage of private septic systems at Long Point and Turkey Point.

Review of the policies and land use/development trends in the last twenty years indicate continued development has occurred in the Long Point area, often at sites prone to flooding and erosion hazards. Jessen et al. (1983) reported that 52% of development applications at Long Point were in flood susceptible areas. A review of all development applications at Long Point (Table 5) indicated that 44% of applications were for new cottages/additions and of these 27 applications, 17 or 63% were approved (Jessen et al., 1983). In the period 1980-1987, 391 building permit applications were issued for community of Long Point (Table 6) (Warner, 1988). The approval of new cottages (5.4%) fell in the previous five years, perhaps as available lots declined in number. However, improvements to existing lots and buildings, including raising and repairs, presumably in response to flooding concerns and previous damages, increased during the same period. From 1980 to 1987, the annual values of these building permits increased from $213,000 to $426,000 at Long Point, with the greatest portion for new cottages ($870,000) and repairs ($1.1 million) (Warner, 1988).

A review of development applications submitted to the RMHN during the last five years (1988-1993) has been conducted. Results indicate that building permits for single family dwellings in the Townships of Delhi and Norfolk show rising trends in number and value. A total of 665 permits were issued in 1988 to 1993 with peak numbers in 1991 (168) and 1992 (165). Declines in the last two years are presumed to reflect poor economic conditions in the real estate market generally. The values of these permits, totalling of $7.7 million in 1992 and $6 million in 1993, indicate continued growth in the construction and redevelopment of the residential market in the Long Point area. From 1989 to October 1993, a total of 286 applications were submitted with the majority (157 or 55%) for minor variations having little if any importance for impacts from flooding and erosion.

Of importance to land use changes and potential damages from shoreline hazards are regional government official plan and municipal township zoning amendments, which approve development types not in accordance with existing municipal zoning designations such as Hazard lands. In the study area, a total of 41 of these applications were submitted in the study area in the last four years. However, only six are located at the cottage community of Long Point and one at Turkey Point indicating little new major development requiring zoning changes. Redevelopment, primarily repair and upgrading with conversion of existing seasonal to permanent residences, continues to occur at Long Point and Turkey Point, as evidenced by increased number of permanent residences (refer to Table 2). This has resulted in increased investment and infrastructure demands at these sites. A more important recent land use trend is the increased interest in larger scale developments, such as marina and condominium complexes, which account for 11 of the 41 applications including the Reynaert (Inner Bay north shore), Ducks Landing (Port Rowan), Aker (Inner Bay north shore), and Captains Cove (Clear Creek, Lake Erie north shore) proposals. It appears that as land has become less available in the Long Point and Turkey Point communities, increasing land use pressures are being placed on adjacent sites with water access to the Inner Bay and Long Point areas.

The current land use trends and management and planning initiatives highlight a concern for continued flooding and erosion hazards and increasing damages in the Long Point study area. Investment in development of larger permanent residences and roadway and infrastructure improvements is increasing land and property values, setting the stage for higher damages during future flooding and erosion events. During the last fifteen years, 1977 to 1992, the number of first tier (lakeshore or waterfront) seasonal residences have increased 10%, seasonal second tier (lakeview) 5.5% and single family residential 15% (Table 7). The risk potential for these areas from hazards has not decreased since the most recent high waters in 1985-86 as historical records show that high water levels, storms and associated flooding and erosion are likely to return.

Management and planning in the Long Point area are very complex, reflecting the wide range of goals and objectives of a variety of private and public agencies. A significant number of agencies support efforts at conservation and protection of species and habitat in the Long Point area which is nationally and internationally known for its natural heritage as reflected by the presence of parks, protected areas and management agreements. Planning for these areas, which includes provisions relating to the flooding and erosion necessary to maintain many of the dunes, wetlands and other key features, has been limited. Very few comprehensive plans or programs have been developed and many existing land use plans make little reference to shoreline flooding and erosion hazards.

The Long Point Region Conservation Authority (LPRCA) has developed a Shoreline Management Plan (SMP) (Philpott Ltd., 1989) which defines key components of a shoreline management program to include: prevention, protection; emergency responses; public information; environment; and monitoring (Ontario Ministry of Natural Resources, 1987). The focus of the plan is on the establishment of a regulatory shoreland zone including a 1:100 year flood uprush limit, 100 year erosion limit, and dynamic beach limit (setback to protect dune and beaches from development). The hazard land use setback reflects the ongoing development of a Provincial Policy Statement for Great Lakes Shoreline Flooding and Erosion by the Ontario Ministry of Natural Resources and anticipated land uses planning reform in Ontario. The SMP also includes description of specific site conditions including: land use and development; rates, frequency and magnitude of hazards; and the risk of damage to property and life.

Table 4. Shoreline Management and Planning in the Long Point Study Area

1973:	Provincial Shoreline Property Assistance Act passed - provides low interest loans to property owners for he construction and rehabilitation of protective works.
1973:	Ontario Ministry of Housing issues Zoning Orders for Townships to be incorporated into RMHN - overrode existing local zoning bylaws until creation of regional government
1973-75:	Great Lakes Shore Damage Survey
1974:	Creation of the Regional Municipality of Haldimand-Norfolk
1974:	Lakeshore Study of Haldimand-Norfolk Counties
1976:	Regional Official Plan Lakeshore Policy adopted 4/26/76 - recommended that all lakeshore development should be stopped until the Lake Erie pollution problem was resolved.
1977:	Preparation of interim management guidelines for Long Point Provincial Park
1978:	Regional Municipality of Haldimand-Norfolk Official Plan approved
1980:	District Plans approved
1980:	Zoning Bylaw of Township of Delhi approved
1980:	Amendment No. 8 to Official Plan - section 11. ` provide for District Plans to allow minor infilling development on private roads within the Lakeshore Area ` - section 12. ` allow replacement of buildings or structures within the Lakeshore Area ` (approved 8/5/82)
1983:	Long Point National Wildlife Area Management Plan
1983:	Lee Brown Waterfowl Management Area Plan
1983:	Long Point Region Conservation Authority Watershed Plan
1984:	Review of Regional Official Plan (5.1. Hazard Lands) - LPRCA suggests rewording of section to reflect consultation with CA regarding amendments to plan in regard to changes to hazard land boundaries
1985:	Official Plan Review: Background Report (Permanent Development in the Lakeshore Area)
1985:	Zoning Bylaw of Township of Norfolk approved
1985:	Amendment No. 6 to the Township of Norfolk District Plan - recognizes existing resort residential development and permits redevelopment and minor infilling on a number of existing lots at the eastern end of Hastings Drive in the resort area of Long Point. ` No new development is permitted because of the inherent hazardous conditions caused by high water levels and wave uprush ` . Changes zoning from `Hazard Land' to 'Long Point' (Zoning Bylaw 1- NO 86)
1986:	Designation of the Long Point World Biosphere Reserve
1986:	Permanent Residential along the Lakeshore: City of Nanticoke Study
1986:	Amendment # 11 to RMHN Official Plan: Lakeshore conversion
1986:	Township of Norfolk passes By-Law 17-No-86 - recognizes existing vacation homes and permits rebuilding, repairs and minor additions but does not permit the construction of a new cottage.
1986:	Amendment # 6 to the City of Nanticoke District Plan - regarding erosion prone areas, adopted May 22, 1986
1987:	Township of Delhi District Plan: Amendment No. 1 to the Official Plan of the Haldimand-Norfolk Planning Area
1987:	Township of Norfolk District Plan: Amendment No. 2 to the Official Plan of the Haldimand -Norfolk Planning Area.
1987:	Long Point-North Causeway Area Secondary Plan: Amendment No. 15 to the Township of Norfolk District Plan - approved by Norfolk Council, then added resort residential development to lands SW of Highway # 59 north of the marsh.
1987:	Review of Town of Haldimand Lakeshore Study
1988:	Amendment No. 25 to the Town of Haldimand District Plan -Permanent Residential Development along the Lakeshore, designation of additional Resort Residential Nodes
1989:	Regional Municipality of Haldimand-Norfolk Rural Policy Study
1992:	Long Point Region Conservation Authority Shoreline Management Plan is completed
1993:	Review of the RMHN Official Plan, release of Issues and Options document

Table 5. Development Applications at Long Point, 1974-1978

Type	Number of Applications		Decisions: Approval		Refusal		No Decision	
	No.	%	No.	%	No.	%	No.	%
new cottage	5	8.2	2	3.3	1	1.6	2	3.3
addition	22	36.1	15	24.6	4	6.6	3	4.9
conversion	0	0	0	0	0	0	0	0
new permanent	0	0	0	0	0	0	0	0
accessory	22	36.1	17	27.9	0	0	5	8.2
relocation/ rebuild	9	14.8	7	17.1	1	1.6	1	1.6
other	3	4.9	1	1.6	0	0	2	3.3
Totals	61		32	52.5	6	9.8	13	21.3

Note: 15 (24.6%) developments had construction prior to application submission (data from Jessen et al., 1983)

Table 6. Building Permit Applications for Long Point and Turkey Point, 1980-1987

Type	Turkey Point		Long Point		Total	
	No.	%	No.	%	No.	%
New Cottage	27	7.9	21	5.4	48	6.5
Raise	81	23.6	14	3.6	95	12.9
Repair	23	6.8	162	41.4	185	25.2
Addition	78	22.8	88	22.5	166	22.6
Alteration	47	13.7	18	4.6	65	8.8
Demolition	19	5.5	11	2.8	30	4.1
Boathouse	16	4.6	30	7.7	46	6.3
Garage	28	8.1	27	6.9	55	7.5
Accessory	15	4.4	8	2.0	23	3.2
Relocate/Rebuild	9	2.6	12	3.1	21	2.9
Total	343		391		734	

Note: no data available for Long Point in 1980 and 1984 (data from Warner, 1988)

Table 7. Long Point Study Area Development Types, 1977-1992

Type	1977	1982	1987	1992	Change	%
Farm with residence	125	128	129	135	6	4.8
Residential						
single family	850	891	922	974	124	14.6
more then one residence	12	12	12	12	0	0
with commercial/industrial	54	56	57	59	5	9.3
multiple residence	19	19	19	20	1	0
mobile home	4	4	4	4	0	0
mobile home park	1	1	1	1	0	0
Seasonal						
first tier	558	576	595	619	61	10.9
second tier	579	589	594	611	32	5.5
not on water	2	2	2	2	0	0
unspecified	4	4	4	4	0	0
Retail	30	32	38	40	10	33.3
golf course	1	1	1	1	0	0
marinas	8	11	12	12	4	50.0
Industrial	7	7	7	8	1	14.3
Institutional	2	2	2	2	0	0
Special Purpose	30	32	33	33	3	10.0
Government	6	6	6	6	0	0
Totals	2283	2361	2425	2530	247	10.8

(source: Ontario Ministry of Finance, Ontario Assessment System, 1992 and RMHN)

Proposed SMP management concepts are presented for selected detailed study sites including; Long Point, Turkey Point, Port Dover, and the shoreline from Peacock Point to Featherstone. The key recommendations of the SMP are: 1. no use of structural protection on the lakeside of Long Point, 2. no new development and modification of seasonal residences at Long Point; 3. designation of Hastings Drive as a `No Re-Build' zone; 4. raising of dwellings on flood prone bayside at Long Point and Turkey Point; 5. flood proofing of any new development at the Port Dover beach; and 6. no new development from Peacock Point to Featherstone Point *unless* all hazards are eliminated by use of shore protection structures.

The SMP has been approved as a policy of the Conservation Authority and is currently used for public information, plan input review, and to support CA recommendations to local and regional governments concerning development proposals such as official plan and zoning bylaw amendments. However the SMP has no legal basis as the LPRCA currently has no approved shoreline land use regulations. Local municipal governments can choose to ignore recommendations and planning review comments from the CA in reference to shoreline development, which is under regulatory control of the area municipalities.

The current Issues and Options Paper for the Regional Official Plan Review (RMHN, 1993) discusses several options concerning lakeshore development: 1 that the regional official plan require amendments to reflect the Provincial Great Lakes-St. Lawrence River Flood and Erosion Policy Statement when approved by the provincial government; 2. that the regional official plan limit expansion of new lakeshore development to existing development nodes; 3. that the regional official plan permit development along the entire shoreline; 4. that the regional official plan allow conversion of resort (seasonal or cottage) residential buildings to permanent residential use at growth nodes along the shoreline (Port Dover, Port Rowan as well as appropriate lakeshore hamlets), and 5. council could retain current policies permitting limited permanent development along the lakeshore, reflecting minimum requirements under Provincial policy, or amend the regional official plan to be more restrictive. Review and public discussion of these options and revisions to the regional official plan are still in progress. In addition, proposed changes to the Ontario Planning Act are currently before the provincial government. These revisions include the introduction of a provincial policy statement on Great Lakes shoreline flooding and erosion hazards and significant reforms to the existing planning process in the province. If approved this policy could be applied to limit land use developments in shoreline hazard areas.

SIGNIFICANCE AND CONSTRAINTS FOR PLANNING AND MANAGEMENT

In order to identify key issues and areas of concern in regards to the hazards of shoreline flooding and erosion, a set of preliminary summary maps has been developed to assess significance and constraints for planning and management in the Haldimand-Norfolk region and the Long Point study area. This assessment is an initial attempt and is intended as a basis for further study and discussion in relation to the importance and impacts of flooding and erosion. Significance was generally identified in terms of the importance of flooding and erosion to key abiotic, biotic or cultural features and processes. The range of significance was assessed by use of a set of criteria defined by the Long Point environmental folio project (Nelson et al., 1993). Diversity refers to the range of natural features. Essential processes refers to the importance of sediment transport, water level changes and other natural processes in maintaining features such as dunes and wetlands. Productivity refers to the value of an area for natural functions such as fish spawning, waterfowl nesting, and biological populations. Equity refers to the need to conserve environments in such as way to provide access to opportunities for current and future generations.

The Lake Erie shoreline was divided into a series of nodes and sections reflecting landform types and land uses as mapped previously in the study (see Figures 8 and 11). Each of these sites was then assessed a rank of high (h), medium (m) or low (l) for each of the criteria: diversity, essential processes, productivity, and equity. Any site with two or more rankings of the same value was given a final total ranking equal to that value (e.g. diversity = h, essential processes = h; productivity = l; equity = m; total rank = H). Constraints were defined by the assessment of site conditions including conflict with land uses, terrain types, and sensitivity of uses to hazards in terms of occurrence, frequency, and magnitude. The areas of constraint reflect the compatibility of flooding and erosion to key natural features or economic activities.

Along the shoreline in Haldimand-Norfolk (Figure 19), the area of the Long Point spit is classified as high significance due to the role of flooding and beach/dune erosion in the maintenance of wetlands, dunes and other biological and landform characteristics of the feature. Medium significance areas at Big Creek and the north shore of the Inner Bay reflect the role of water level fluctuations in wetland succession and diversity (IJC, 1989). The majority of remainder of the Haldimand-Norfolk shoreline is classified as a constraint for planning and management as land uses in these areas, such as agriculture and tourism are important for local economies and these areas are impacted by flooding and erosion.

Within the Long Point study area (Figure 20), flooding and erosion are important processes in maintaining beaches and dunes on the spit. The marshes of Big Creek and the north shore of the Inner Bay are of medium significance as flooding and erosion supports productivity and diversity of fauna and flora, thus providing importance habitats for wildlife, bird and fish species as well as rare and threatened vegetation. High density residential development located at Hastings Drive, the first tier Long Point cottages, sites adjacent to the Provincial Crown marshes, along the Long Point Causeway, and cottages at Turkey Point represent current land uses which are in conflict with continued and persistent shoreline flooding and erosion and are areas of constraint for planning and management.

DISCUSSION

Our understanding of flooding and erosion hazards is incomplete. A lack of information exists concerning the environmental impacts of shoreline protection structures especially the interruption of alongshore sediment transport by groynes, jetties, and harbour structures and the reduction of sediment supply from bluffs. Detailed assessment of site conditions in flood and erosion prone areas is necessary including baseline studies and regular monitoring. Environmental assessment of proposed development along shorelines such as marina, residential, and harbour facilities should be required in order to determine possible impacts of flooding and erosion and their capacity to interfere with wildlife, wetland or other functions and values as well as nearby land uses.

Public perception that high water levels are the major cause of flooding and erosion continues, along with associated support for government control of lake levels by use of control and diversion works. This perception fails to recognize the role of storm events, long term natural erosion and flooding, and the limited effectiveness and high economic and environmental costs of water level control works. The preoccupation with water level regulation also continues to ignore human activity and land uses as part of the problem and the solution. The IJC lake level reference study final report (IJC, 1994) recommended to government that future water level regulation not be pursued due to limited ability to reduce storms and short term water levels and the resulting damages, the detrimental environmental impacts of water level regulation on wetlands and other natural features and processes, and the high costs of regulation structures resulting in unequal benefits to the variety of users that would be affected.

Kreutzwiser (1982) has made these observations in regard to attempts to manage continued flooding and erosion on the Great Lakes shoreline: 1. damages from flooding and erosion are recurring and costly in spite of continuing attempts to protect properties with structures; 2. responsibility for natural hazards is highly fragmented among many agencies and levels of government; 3. there is a tendency to look for expedient solutions during times of crisis; and 4. there is too much reliance on shore protection works that attempt to deal with the biophysical rather then the human roots of the hazard problem.

In recent years several key studies have identified the need to move towards a type of shoreline planning based on understanding the wide range of issues that are important in shoreline planning and management. Many refer to this planning method or idea as an ecosystem approach. Examples include the Royal Commission on the Future of the Toronto Waterfront (1992), the international Earth Summit and Agenda 21 and the recent World Coast conference, the Commission on Planning and Development Reform in Ontario (1993), and the recent International Joint Commission Levels Reference Study (1994). There is a growing concern and renewed interest in management of the environment in a more complete manner with full and due regard to the human and natural factors that may influence use of the landscape. The underlying interest is in long term sustainable use and protection of the shoreline.

Figure 19. Haldimand-Norfolk Region Significance and Constraints

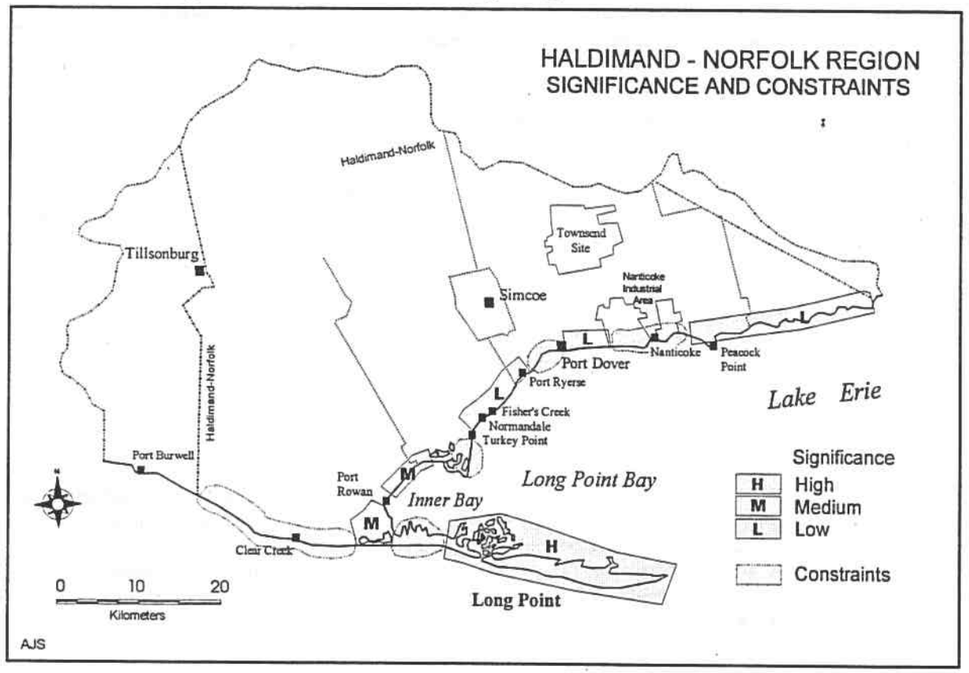
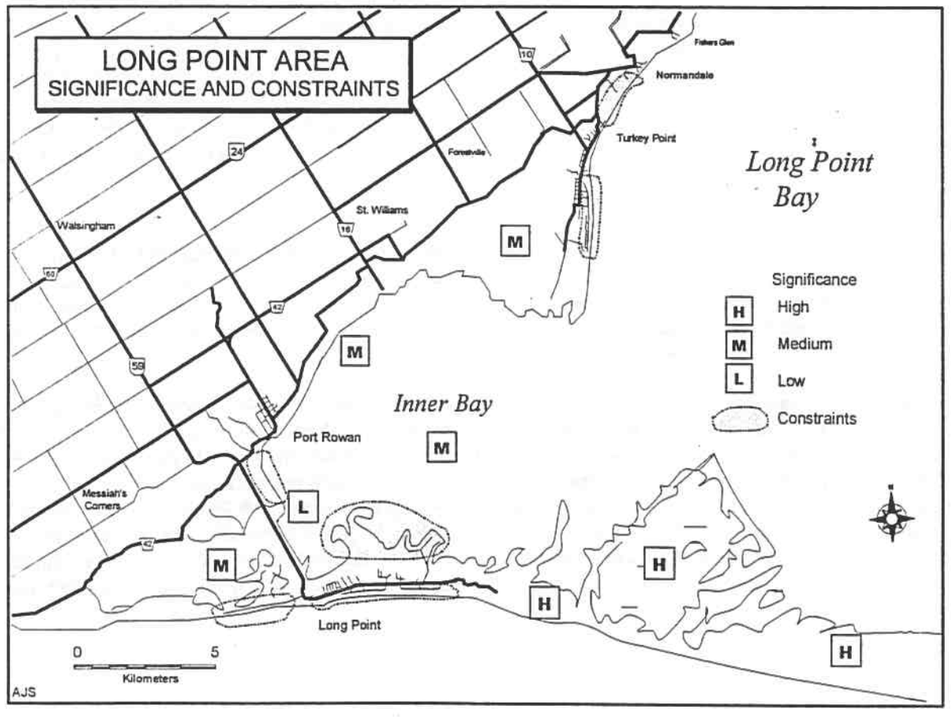


Figure 20. Long Point Area Significance and Constraints



CONCLUSIONS

This study has attempted to summarize and highlight the natural and human factors that characterize flooding and erosion hazards in the Haldimand-Norfolk lakeshore and Long Point study area. There is an ignorance of the range of factors that contribute to flooding and erosion hazard, with a focus on physical processes that occur naturally. Management responses focus on attempts to reduce the costs by use of shore protection structures and not controlling land uses in flood and erosion prone areas. Continued occupance and development of shoreline sites is occurring in areas prone to flooding and erosion. Management of shoreline flooding and erosion on Lake Erie and within the study area is characterized by the inability of traditional government programs to deal with reoccuring damages and increased development in shoreline hazard areas. Inadequate enforcement of land use control regulations has allowed amendments and exceptions to existing municipal official plans and zoning bylaws and has permitted continued development and increasing damages. This is leading to increased public and private investment in areas, very likely to suffer increased damages during future flooding and erosion.

Several recommendations can be made in the spirit of resolving land use conflicts, and reduction of damages and losses from shoreline flooding and erosion hazards. These recommendations basically involve balancing attempts to modify the cause of hazards by use of shore protection and lake level controls with regulatory and behavioral approaches such as land use planning and control of development, removal of buildings from hazard prone sites, and greater use of economic incentives to reduce development in hazard areas.

1. Public information programs are needed which involve people in educational and other activities that create improved general understanding of the inevitability of shoreline flooding and erosion, especially in highly susceptible areas. Such programs should stress how shore protection structures exacerbate flooding and erosion and also conflict with attempts to maintain wetlands, dunes, beaches and other features that created Long Point and are essential to its long term sustainability.

2. Studies are needed to monitor and assess land use changes and their environmental impacts, as well as to evaluate government policies and programs to ensure proper compliance and enforcement of shoreline hazard management measures.

3. There is a need to improve our understanding of the natural processes that lead to shoreline flooding and erosion hazards. This would require improved research on: forecasting long-term water level fluctuations, the dynamics of nearshore sediments, documenting and monitoring shoreline changes, and assessment of the environmental impact and integrity of structural shore protection structures.

4. Governments should consider strategies to provide economic incentives to reduce the damages from shoreline flooding and erosion hazards. Low interest loans and grants, such those utilized by the Clean Up Rural Beaches Program (CURB), could be provided in appropriate risk areas to promote non-structural attempts at shore protection including dune and beach nourishment, dune vegetation planting, and relocation. Programs should be developed to consider alternative uses of areas impacted by severe flooding and erosion, such as Hastings Drive on Long Point, resulting in decrease in long term and continued damages in these areas while supporting development of low risk sites.

REFERENCES

Boyd, G.L. (1981). *Canada/Ontario Great Lakes Erosion Monitoring Programme 1973-1980 - Final Report*. Environment Canada, Inland Water Directorate, Burlington, Ontario.

Cain, K.G. (1988). *Fluctuating Great Lake Water Levels and Ontario Provincial Parks: A Call for Coastal Management*. unpublished MA Thesis, Department of Geography, University of Waterloo.

Coakley, J.P. (1983). *Sub-Surface Sediments and Late Quaternary history of Long Point, Lake Erie.* NWRI Contribution 84-43, Environment Canada, Canada Centre for Inland Waters, Burlington, Ontario.

Commission on Planning and Development Reform in Ontario. (1993). *New Planning for Ontario: Final Report Summary & Recommendations*. Queen's Printer Ontario, Toronto, Ontario.

Davidson-Arnott, R.G.D. (1988).` Temporal and Spatial Controls on Beach/Dune Interaction, Long Point, Lake Erie `. *Journal of Coastal Research* Special Issue # 3, pp. 131-136.

Davidson-Arnott, R.G.D. and Fisher, J.D. (1992) ` Spatial and temporal controls on overwash occurrence on a Great Lakes barrier spit `. *Canadian Journal of Earth Science* 29(1), pp. 102-117.

Davidson-Arnott, R.G.D. and Kreutzwiser, R.D. (1985).' Coastal Processes and Shoreline Encroachment: Implications for Shoreline Management in Ontario'. *The Canadian Geographer* 29(3), pp. 256-262.

Davidson-Arnott, R.G.D. and Law, M.N. (1990). ` Seasonal Patterns and controls on sediment supply to coastal foredunes, Long Point, Lake Erie`. In *Coastal Dunes: Form and Process* (editors K.F. Nordstrom, N.P. Psuty and R.W.G. Carter), pp. 177-200.

Ecologistics Ltd. (1992). *Private and Public Shore Protection Expenditures along the Canadian Great Lakes-St. Lawrence River Shoreline, 1985-1987*. Report prepared for International Joint Commission Levels Reference Study Working Committee 2, Windsor, Ontario.

Environment Canada/Ontario Ministry of Natural Resources (1975). *Canada/Ontario Great Lakes Shore Damage Survey - Technical Report* Government of Ontario Printer, Toronto, Ontario.

Environment Canada/Ontario Ministry of Natural Resources (1976). *Great Lakes Coastal Zone Atlas* (editors: W.S. Haras and K.K Tsui). Canada/Ontario Great Lakes Shore Damage Survey, Toronto, Ontario.

Francis, G.R., Grima, A.P., Reiger, H.A., and Whillans, T.H. (1985) *A Prospectus for the Management of the Long Point Ecosystem* Great Lakes Fishery Commission Technical Report No. 43, Ann Arbour, Michigan.

Fraser, J.A., Day, J.C, Kreutzwiser, R.D. and Turkheim, R.J.(1977). ` Residents' Utilization of Coastal Hazard Assistance Programs in the Long Point Area, Lake Erie `. *Canadian Water Resources Journal* 2(2), pp. 37-50.

Gelinas, P.J. and Quigley, R.M. (1973). ` The Influence of Geology on Erosion Rates along the North Shore of Lake Erie `. In *Proceedings of the 16th Conference on Great Lakes Research*, Ann Arbor, Michigan, pp. 421-430.

Geomatics Ltd. (1992). *Great Lakes Shoreline Classification and Mapping Study: Canadian Side*. Final Report for International Joint Commission Levels Reference Study, Windsor, Ontario.

Great Lakes Basin Commission (1976). *Great Lakes Basin Framework Study.* Ann Arbor, Michigan.

International Joint Commission (1989). *Living with the Lakes: Challenges and Opportunities* A Progress Report submitted by the Project Management Team, Water Levels Reference Study Phase I, Windsor, Ontario.

International Joint Commission (1990). *Great Lakes-St. Lawrence Shoreline Riparian Survey: Preliminary Results*. Report of Working Committee 2 Levels Reference Study Board, Burlington, Ontario.

International Joint Commission (1993). *Land Use and Management -Draft Final Report of Working Committee 2*. Levels Reference Study Board, Burlington, Ontario.

International Joint Commission (1994). *Final Report of Levels Reference Study Great Lakes- St. Lawrence River Basin* Levels Reference Study Board, Windsor, Ontario.

Jessen, S. and Day, J.C. (1980). ` Regulating Great Lakes Flood and erosion Hazards: The Haldimand-Norfolk experience, Lake Erie, Ontario'. In *Water Problems and Policies* (edited by W.R.D. Sewell and M.L. Barker), pp. 13-24.

Jessen, S., Day, J.C. and Nelson, J.G. (1983). ` Assessing Land-use Regulations in Coastal Wetlands: The Case of the Long Point Area, Lake Erie, Ontario `. *Coastal Zone Management Journal* 11(1-2), pp. 91-115

Kreutzwiser, R.D. (1977). *An Evaluation of Lake Erie Shoreline Flood and Erosion Hazard Policy*. unpublished Ph.D. thesis, Department of Geography, University of Western Ontario, London, Ontario.

Kreutzwiser, R.D. (1982). ` An Evaluation of Government Response to the Lake Erie Shoreline Flood and Erosion Hazard `. *Canadian Geographer* 26(3), pp. 263-272.

Kreutzwiser, R.D. (1988). ` Municipal Land use Regulation and the Great Lakes Shoreline Hazard in Ontario `. *Journal of Great Lakes Research.* 14(2), pp. 142-147.

Kreutzwiser, R.D. (1987).` Managing the Great Lakes Shoreline Hazard `. *Journal of Soil and Water Conservation* 42(3), pp. 150-154.

Lake Erie Task Group (1969). *Lake Erie Shore Inventory*. Toronto, Ontario.

Needham, R.D. and Nelson, J.G. (1978).' Adjustment to Change in Coastal Environments: The Case of Fluctuating Lake Erie Water Levels `. In *Proceedings of the Fourth Annual Conference of the Coastal Society, Coping with the Coast*, pp. 196-213.

Nelson, J.G., Lawrence, P.L., Beazley, K., Stenson, R., Skibicki, A., Yeung, C.L. and Pauls, K. (1993) *Preparing an Environmental Folio for the Long Point Biosphere Reserve and Region*. Long Point Environmental Folio Publication Series Working Note 1 (managing editors, J.G. Nelson and P.L. Lawrence), Heritage Resources Centre, University of Waterloo, Waterloo, Ontario.

Ongley, E.D. 1976. `Sediment Yields and nutrient loadings from Canadian watersheds tributary to Lake Erie: an overview'. *Journal of Fisheries Research Board of Canada*. 33, pp. 471-484.

Ontario Ministry of Natural Resources (1987). *Guidelines for Developing Great Lakes Shoreline Management Plans*. Report to the Ontario Conservation Authorities, Toronto, Ontario.

Ontario Shoreline Management Review Committee (1986). *Report of the Shoreline Review Committee to the Ministers of Natural Resources and Municipal Affairs*. Province of Ontario, Toronto, Ontario.

Philpott Ltd. (1989). *Shoreline Management Plan.* Long Point Region Conservation Authority, Simcoe, Ontario.

Rasid, H., Baker, D. and Kreutzwiser, R.D. (1992). ` Coping with Great Lakes flood and erosion hazards: Long Point Lake Erie vs. Minnesota Point, Lake Superior `. *Journal of Great Lakes Research* 18(1), pp. 29-42.

Regional Municipality of Haldimand-Norfolk (1976). *Policies for the Regulation of Lakeshore Development - A Technical Report.* Planning and Development Department, Cayuga, Ontario.

Regional Municipality of Haldimand-Norfolk (1986) *Haldimand-Norfolk Lakeshore Damage Survey : Summary of December 2, 1985.* Damage Survey Conducted by the Economic Development Department of the Region of Haldimand-Norfolk. Townsend, Ontario.

Regional Municipality of Haldimand-Norfolk (1993) *Issues and Options Paper.* Regional Official Plan Review-Stage 2, Regional Planning Department, Townsend, Ontario.

Reinders Ltd. (1988). *Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes.* Report to the Ontario Ministry of Natural Resources, Toronto, Ontario.

Royal Commission on the Future of the Toronto Waterfront (1992) *Regeneration.* Queen's Printer of Ontario, Toronto, Ontario.

Rukavina, N.A. and Zeman, A.J. (1987).` Erosion and Sedimentation along a Cohesive Shoreline-The North-Central Shore of Lake Erie `. *Journal of Great Lakes Research* 13(2), pp. 202-217.

Saunders, K.E. and Davidson-Arnott, R.G.D. (1990).` Coastal Dune Responses to Natural Disturbances `. In *Proceedings of the 1990 Canadian Symposium on Coastal Sand Dunes*, National Research Council of Canada, Ottawa, Ontario pp. 321-346.

Skibicki, A. (1993). *The Long Point Region: An Institutional and Land Tenure History and examination of Management Needs.* Long Point Environmental Folio Publication Series Working Paper 3 (managing editors, J.G. Nelson and P.L. Lawrence), Heritage Resources Centre, University of Waterloo, Waterloo, Ontario.

St. Jacques, D.A. and Rukavina, N.A. (1973). ` Lake Erie Nearshore Sediments - Mohawk Point to Port Burwell, Ontario `. In *Proceedings of the 16th Conference of International Association for Great Lakes Research,* pp. 454-467.

Stenson, R. (1993). *The Long Point Area: An Abiotic Perspective.* Long Point Environmental Folio Publication Series Technical Paper 2 (managing editors, J.G. Nelson and P.L. Lawrence), Heritage Resources Centre, University of Waterloo, Waterloo, Ontario.

Stewart, C.J. and Davidson-Arnott, R.G.D. (1988). ` Morphology, Formation and Migration of Longshore Sandwaves; Long Point, Lake Erie, Canada `. *Marine Geology* 81, pp. 63-77.

Warner, W.R. (1988). *A Study of Shoreline Planning in Ontario*: *The Region of Haldimand-Norfolk.* unpublished undergraduate thesis, Department of Geography, University of Western Ontario.

Weller, P. (1989) *Interests and Concerns of Non-Governmental groups in the Long Point Area.* A Report to the Long Point Biosphere Reserve Committee, University of Waterloo, Ontario.

Yee, P. and Cuthbert, D. (1985). *A Report on the 1985 Record High Water Levels of the Great Lakes.* Inland Waters Directorate, Environment Canada Report, Burlington, Ontario.