

shoreline management program

watershed plan



the metropolitan toronto and region conservation authority

SHORELINE MANAGEMENT PROGRAM

THE METROPOLITAN TORONTO AND REGION
CONSERVATION AUTHORITY

SHORELINE MANAGEMENT PROGRAM

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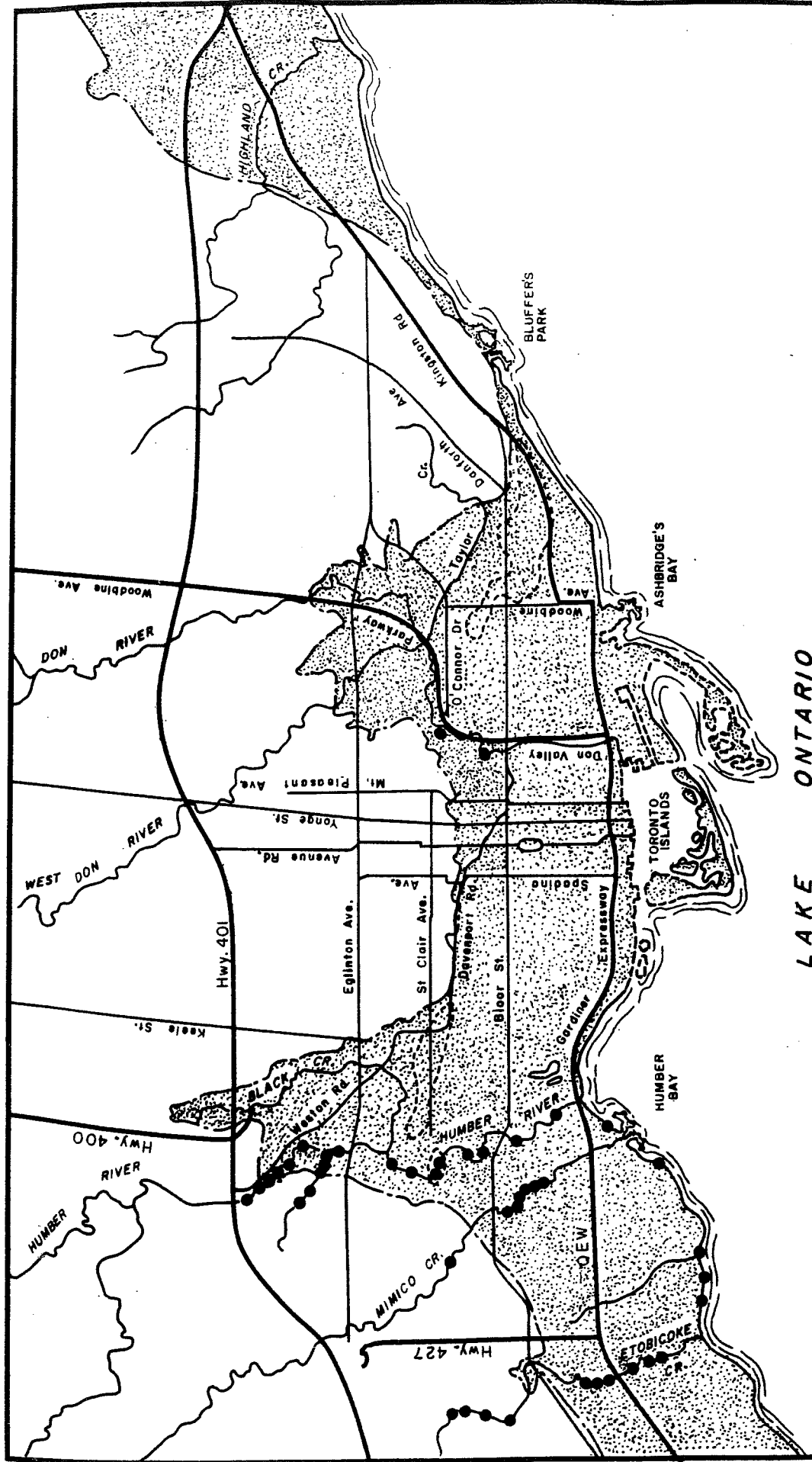
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1. INTRODUCTION

High lake levels, combined with strong winds and high waves, have periodically eroded shoreline properties, flooded homes, or damaged structures throughout the history of the Toronto area. In spite of this potential hazard, development pressures and the desire to live near the lake have resulted in many homes being located in areas vulnerable to erosion and/or flooding. In the next few decades a large number of homes and a substantial amount of shoreline property will be lost. While the immediate installation of shoreline protection would still not save all of the threatened homes, unless a comprehensive program is undertaken an ever increasing number of properties will become endangered in the years ahead. The Authority's Shoreline Management Program is designed to prevent the loss of life and limit the loss of property, due to shoreline hazards throughout its area of jurisdiction.

The shorelines of the lower Great Lakes resulted, in part, from the deposition of varying depths of sediment during the Pleistocene era of glaciation. The sediment comprising the shorelines is generally a mixture of sands, silts, clays, tills and gravels, which are highly erodible. As a result, the shorelines have been, and continue to be, modified by wave attack, the wave climate, groundwater conditions, wind erosion and numerous other factors. In urban areas where development patterns have not been fully cognizant of this phenomenon serious loss of property and threats to houses, roads and services can occur. This is the case along much of the shoreline under the jurisdiction of The Metropolitan Toronto and Region Conservation Authority.



- Lake Iroquois shoreline
- - - Lake Iroquois baymouth bar, gravel and sand
- Bedrock outcrops

Data Derived From
 Freeman, E.B.
 1976: Toronto's Geological Past
 - on Introduction,
 Ontario Div. Mines, Misc. Publication



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WATERSHED PLAN SHORELINE MANAGEMENT PROGRAM

LAKE IROQUOIS SHORELINE

protection varies greatly, from placement of fill and rubble material to well constructed reinforced concrete seawalls. The erosion rates throughout this sector are generally low, but severe damage can occur to many of the protective structures during periods of high lake levels and severe storm conditions. Flooding of some low-lying areas also occurs at high lake levels.

Two serious erosion problems along the Etobicoke shoreline were corrected by the Authority in 1973. Borough of Etobicoke parklands were protected at Long Branch Park and Prince of Wales Park. In both projects the protection consisted of a combination of an armour stone revetment and a groyne to retain a small protective beach (Photos 1 and 2).

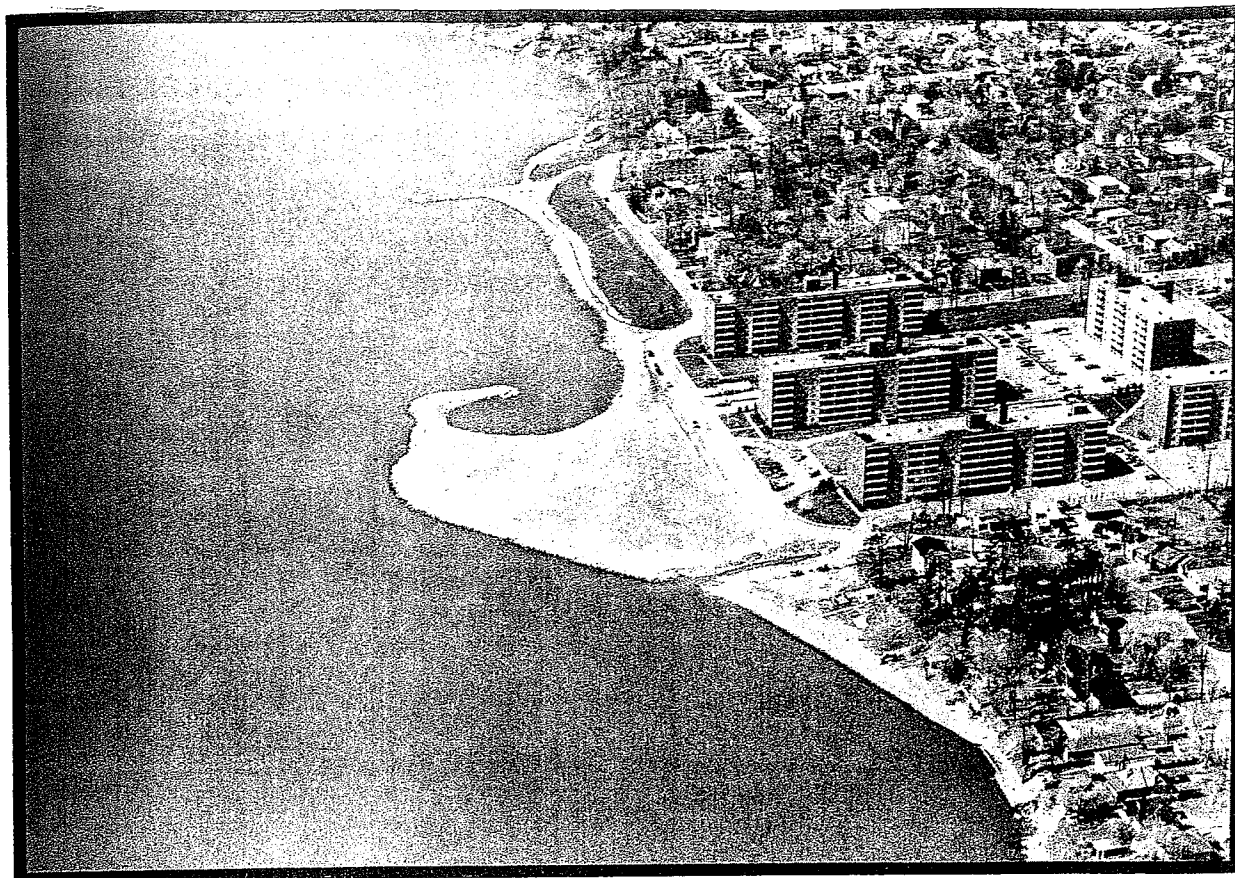
The shoreline protection benefits of the Authority's Humber Bay Project, centred on the mouth of Mimico Creek, are significant. Wave energy, which previously caused regular damage to a shoreline length of approximately 2 km, is intercepted by the landfill.

2.1.2 City of Toronto

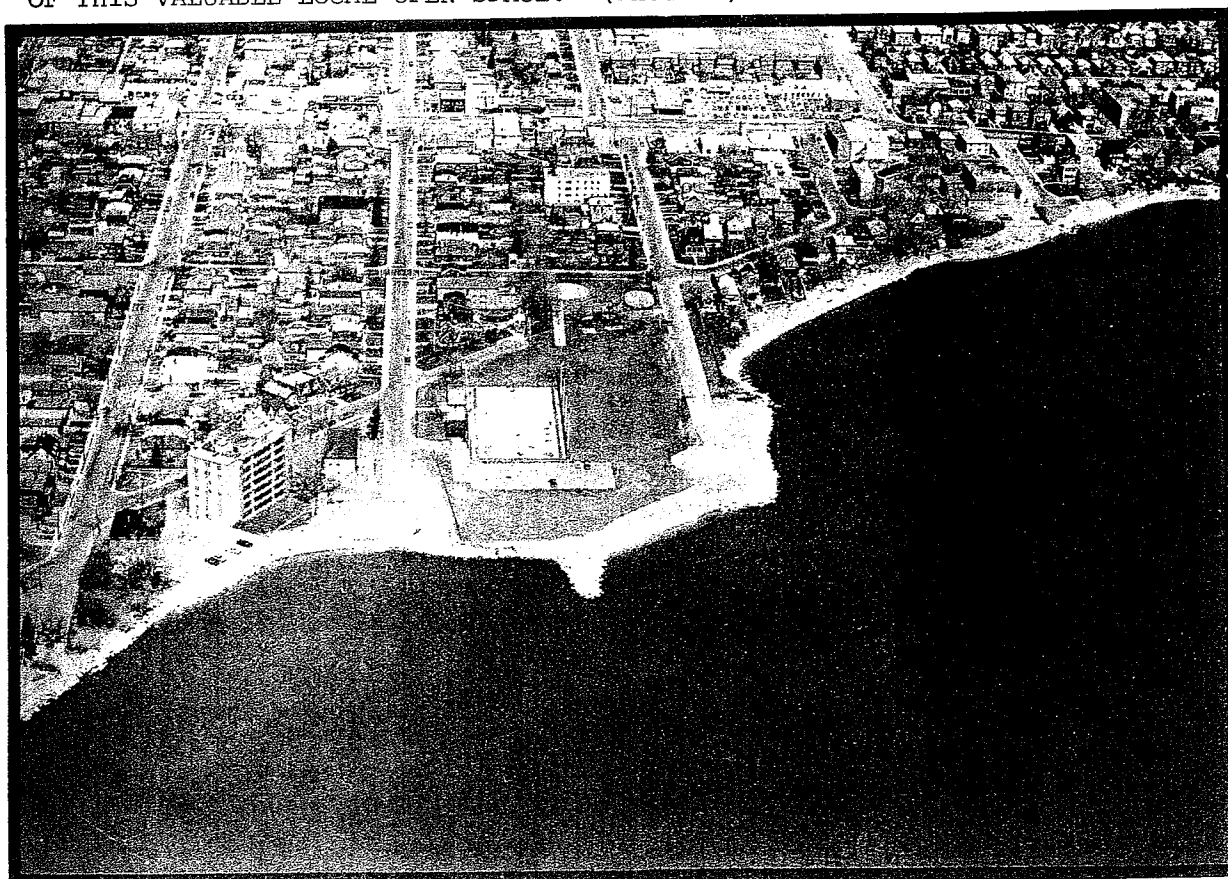
Most of the shoreline in the City of Toronto has been altered by filling or shore protection to provide for either recreational or port-related development. This sector extends from the Humber River, in the west, to Nursewood Road, in the east, a distance of approximately 20.1 km. The Western Beaches sector, which stretches from the Humber River to Ontario Place, is protected by an offshore breakwater which was constructed by 1922. The structure consists of a stone-filled timber crib with a concrete cap and has served its purpose well with minimum maintenance since its original construction. A severe storm in January of 1978 caused some damage to the breakwater in the area of the Toronto Sailing and Canoe Club, which was subsequently repaired by the Federal government in 1978.

The port area of the City of Toronto is protected by Toronto Island and Aquatic Park. Much of the exterior shoreline of Toronto Island has been protected over the years, with the exception of Gibraltar Point. Sand eroded from Gibraltar Point tends to move northerly and westerly towards the Toronto Island Airport, as well as easterly. The shoreline east of Gibraltar Point, which was originally protected by a combination of concrete seawalls, groynes and offshore breakwaters, is now further protected by Aquatic Park. This new man-made landform effectively intercepts much of the wave energy resulting from easterly winds.

The exterior shoreline of Aquatic Park has been protected, during construction, by a series of headlands and beaches which have been nourished regularly with large volumes of concrete, asphalt and brick rubble. The principle of the design is to create a number of beaches which are oriented at 90 degrees to the net wave energy approach direction. All these beach units are partially contained by headlands or hardpoints at either end. In this manner, relatively steep, coarse beaches can be constructed with surplus demolition material provided at no cost



THE PROTECTION OF LONG BRANCH PARK IN ETOBICOKE WAS COMPLETED BY THE AUTHORITY IN 1974 TO STABILIZE THE FILLED AREA AND PREVENT THE LOSS OF THIS VALUABLE LOCAL OPEN SPACE. (PHOTO 1)



PRINCE OF WALES PARK SUFFERED SEVERE EROSION DURING THE HIGH LAKE LEVEL PERIOD OF 1973. SHORE PROTECTION WAS INSTALLED BY THE AUTHORITY EARLY IN 1974. (PHOTO 2)



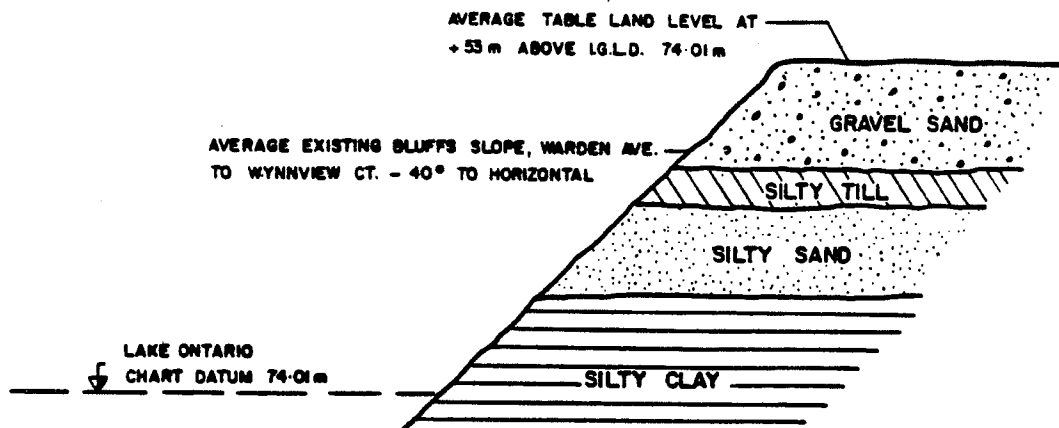
EASTERN BEACHES: THE POPULAR BOARDWALK WAS DESTROYED IN THIS AREA IN 1973. SHORELINE PROTECTION CONSTRUCTED BY THE AUTHORITY IN 1979 INCLUDED A WIDE PROTECTIVE BEACH. (PHOTO 3)



EASTERN BEACHES: LARGE ARMOUR STONE WAS PLACED TO CREATE BEACH ANCHORS. (PHOTO 4)

supplemented in the 1950's (Photo 5). Although seriously damaged in the high water period of 1973, the groyne field held a protective beach which prevented wave attack from actively undermining the toe of the slope. Since the failure of a portion of the groyne field in 1973, some recurrence of toe erosion is evident, with the resultant failure in the bank above to be expected. The reestablishment of adequate toe protection along the Hunt Club property is essential to the long term stability of this area of the bluff face.

East of the Hunt Club property the stability of the bluff face deteriorates rapidly. Figure 2 shows a representative profile of the bluff face between Warden and Birchmount. Throughout most of this area only a narrow beach exists to protect the toe of the bluff against wave attack. Therefore, during periods of high lake levels and storm conditions, the toe of the bluff is undermined, leading to subsequent failure of the bank above. In addition to the wave erosion problem, the bluff contains two sand layers carrying high volumes of groundwater which emerge on the bluff face. These sand layers have gradually been eroded by the groundwater flow at the face of the bluff, resulting in failure of the overlying strata.



TYPICAL BLUFF PROFILE

FIG. 2

Some evidence of the stabilizing effect of appropriate toe protection is available in this area. Near the foot of Harding Boulevard the headwall protection for storm sewers has allowed a relatively stable slope to become vegetated behind the sheet steel piling (Photo 6). Similarly, the slope behind the protective armour stone revetment installed by the Authority in 1979 will have an opportunity to stabilize and become vegetated, since the talus will no longer be removed on a regular basis by wave action (Photo 7).

The area east of Birchmount Road has characteristics similar to those described above. In most cases the only protection to the toe of the bluff is a narrow sand beach which, during periods of high water, is totally submerged. The only structural protection afforded is in the area adjacent to storm sewer outfalls

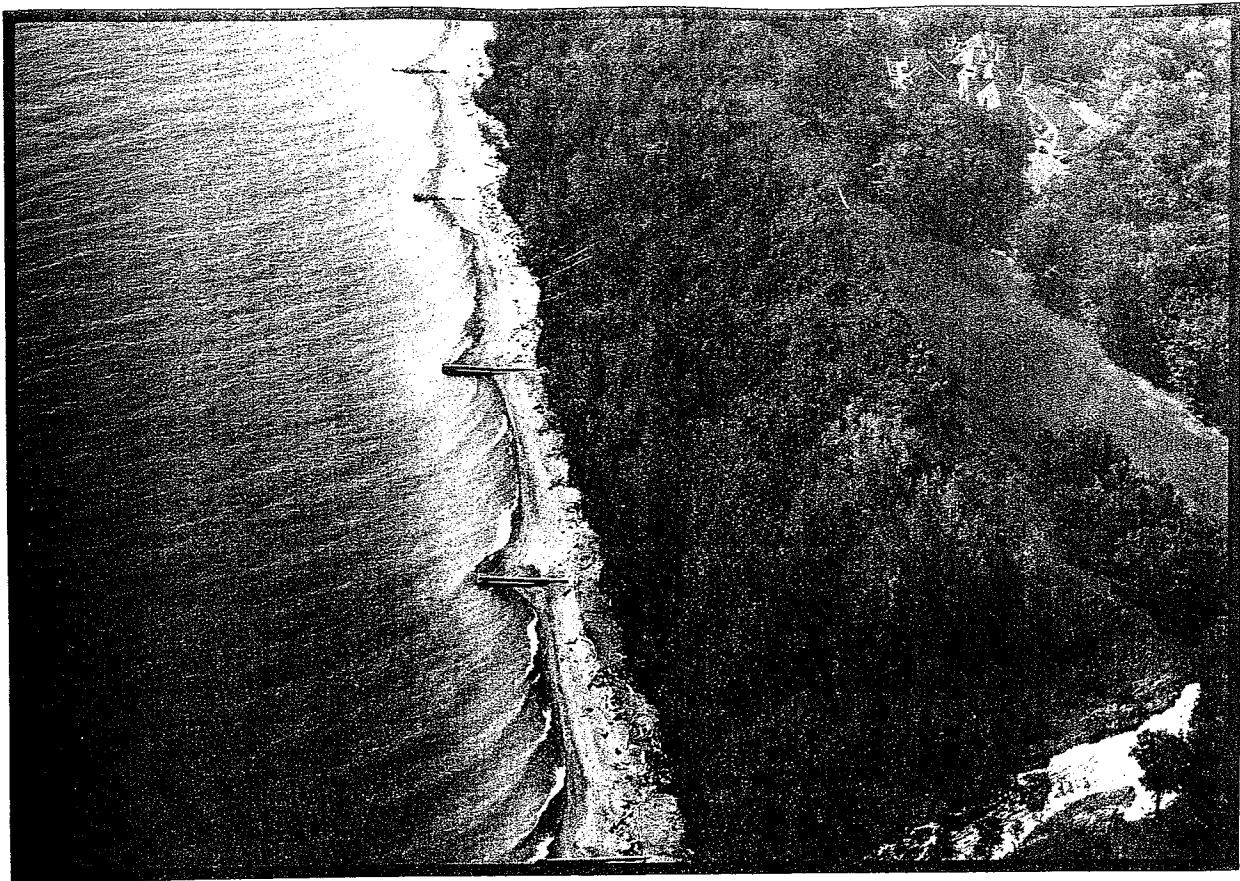
and at the pumping station at Fishleigh Drive. Throughout this area as well, groundwater seepage and subsequent bank failures are a major cause of erosion. The stratigraphy of the bluffs changes dramatically through the section known as Needles Bluffs along Fishleigh Drive. In this area the sand layers are virtually non existent and the hard clay and tills stand nearly vertical. This is the most spectacular section of the bluffs and is now visible from Bluffers Park.

The Bluffers Park project provides protection to approximately 1.6 km of shoreline in this area. The second phase of the project was built in front of the section of the bluffs known as the Cathedral Bluffs. It is in this area that the bluffs reach the highest elevation, as this is the point at which the old Lake Iroquois shoreline meets the present-day Lake Ontario shoreline. Although the toe of the bluff is protected by the Bluffers Park project, the slopes in many areas are still subject to erosion as a result of groundwater seepage. These slopes are expected to continue to erode until they become less steep and vegetation becomes established.

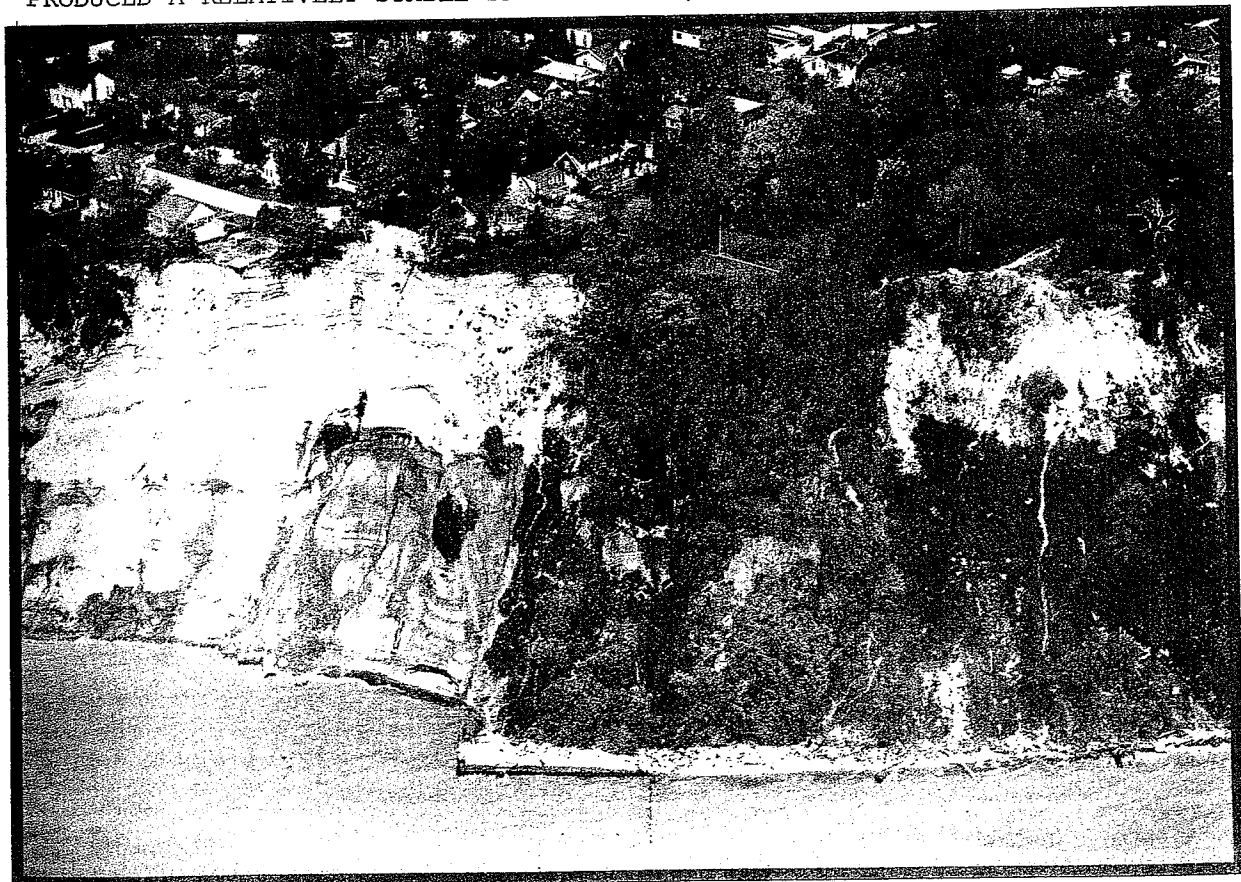
East of Bluffers Park, the cliffs are approximately 65.0 m high and, as with the area west of Bluffers, are generally subject to steady erosion resulting from wave attack, groundwater seepage and other factors. The beach throughout this area is again quite narrow and often submerged during high water periods. The only substantial shore protection is along the Guild Inn property just east of Livingston Road. The initial stage in the protection of this property involved the sinking of three barges just east of Livingston Road to serve as offshore breakwaters to retain a beach in front of the bluff. Following the installation of these barges, a major program of filling was undertaken to construct a berm of earth fill against the original bluff face. The new fill was protected to some extent on the lakeward side by the dumping of concrete rubble (Photo 8). In some areas the terraced fill material reached an elevation approximately halfway up the original bluff face. Although the filling program has been reasonably successful in reducing the rate of recession of the top land, the lakeward face of the new fill is subject to erosion during periods of storm activity. One of the most important aspects of the filling program in this area is the creation of an access point to facilitate shoreline management works, both to the east and west of this property.

In the area east of the Guild Inn, along Guildwood Parkway, the shoreline is again devoid of any significant shoreline protection and is subject to high rates of loss, due primarily to active undercutting of the bank by wave attack. Some filling programs have been undertaken by individual property owners and, as a result, a temporary reduction in loss of tableland has been achieved. The bluffs gradually decrease in height throughout this area to the East Point Park location on the west side of Highland Creek. The shore cliffs here are approximately 10.7 m high but are still subject to rapid erosion, particularly during periods of high water.

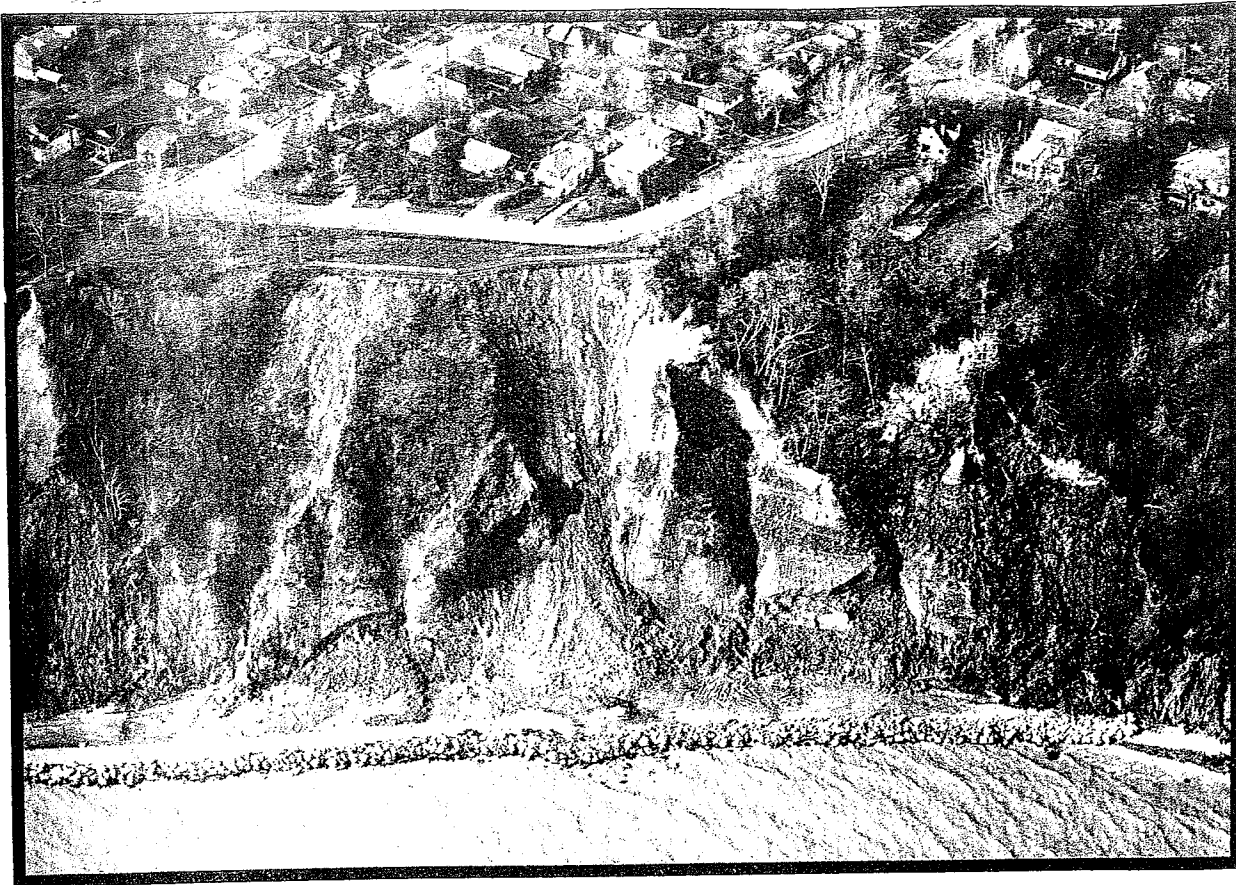
The Chesterton shores area of Scarborough, located just east of Highland Creek, is one of the few areas in the Borough where considerable private attempts have



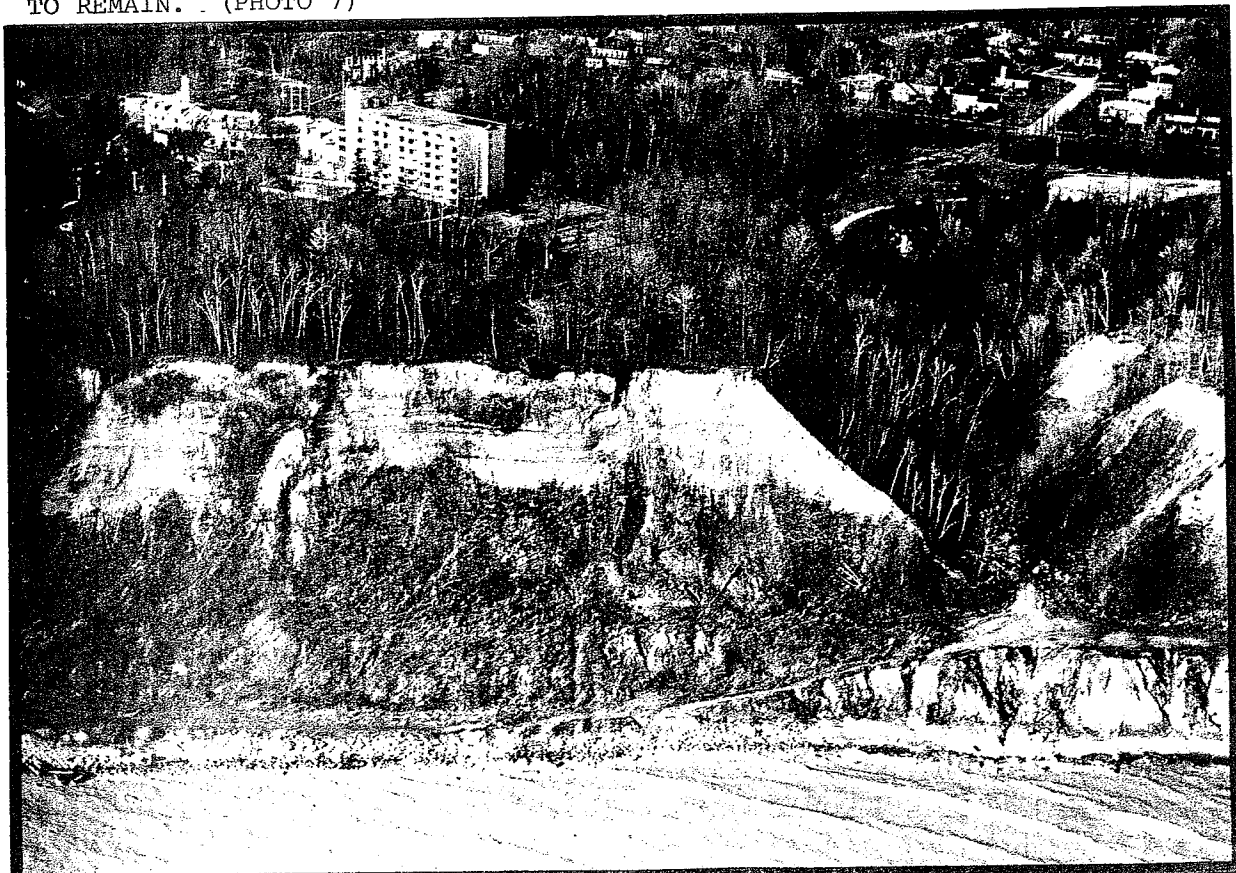
SEVERAL DECADES OF WORK BY THE TORONTO HUNT CLUB TO PROTECT THE TOE OF THE BLUFF, DRAIN THE FACE OF THE BLUFF AND ESTABLISH VEGETATION HAVE PRODUCED A RELATIVELY STABLE SHORELINE. (PHOTO 5)



KINGSBURY/HARDING: THE EFFECT OF TOE PROTECTION ON TALUS STABILITY IS APPARENT HERE BUT THE IMPACT ON ADJACENT SHORELINES MUST BE CAREFULLY CONSIDERED. (PHOTO 6)



THE ARMOUR STONE REVETMENT CONSTRUCTED AT CRESCENTWOOD PARK IN 1979 WILL PROTECT THE TOE OF THE BLUFF AGAINST WAVE ATTACK AND ALLOW TALUS MATERIAL TO REMAIN. . (PHOTO 7)



FILLING AT THE BASE OF THE BLUFFS AND PLACEMENT OF CONCRETE RUBBLE ALONG THE SHORELINE BY THE FORMER OWNER OF THE GUILD INN PROVIDED SOME PROTECTION TO THIS SHORELINE AND AN ACCESS ROUTE TO THE SHORELINE. (PHOTO 8)

been made at reducing shoreline erosion. Many of the structures which had been installed in this area were destroyed during the high water period of 1973 and became endangered. The remaining properties have been fortified with a variety of structural techniques, the majority of which make use of gabion baskets. Most of the remainder of the shoreline in the Borough of Scarborough consists of a heavily protected railway embankment. The exception to this pattern is the sand beach to the west of the mouth of the Rouge River. The beach in this area is quite wide and appears to be relatively stable.

2.1.4 Pickering/Ajax

The physical characteristics of the Pickering/Ajax shoreline are dramatically different from the Scarborough shoreline. This sector of shoreline ranges from low-lying marsh to 12 m bluffs. The configuration of the shoreline consists of prominent headlands at the Pickering Nuclear Generating Station site, as well as at locations just east of the mouths of Duffin Creek and Carruthers Creek. These headlands contain bay formations of various sizes. The predominant bay in the area is Frenchman's Bay, where sand spits have formed and represent a good example of a typical bay mouth bar. The other smaller bays along this section of shoreline rely on nourishment from the sediment loads of the watercourses which outfall to the lake.

In areas where private development has occurred along the shoreline, various types of shoreline protection have been installed. Most of the work is of a temporary nature and is subject to considerable damage during high water periods. Fortunately, much of the shoreline throughout this sector is designated for acquisition by the Authority. In fact, a substantial portion of this shoreline has already been purchased by the Authority. In areas of the shoreline acquired by the Authority in advance of development, no shoreline protection exists.

Unlike the Scarborough section of the shoreline, where virtually no areas are flood vulnerable, in Pickering and Ajax one of the most serious hazards relates to flooding during periods of high lake levels. The Frenchman's Bay area and the Pickering Beach area both suffered serious damage due to flooding, as well as erosion, during the 1973 period of high water. It was during that time that the Authority acquired much of the existing land base in these hazardous areas.

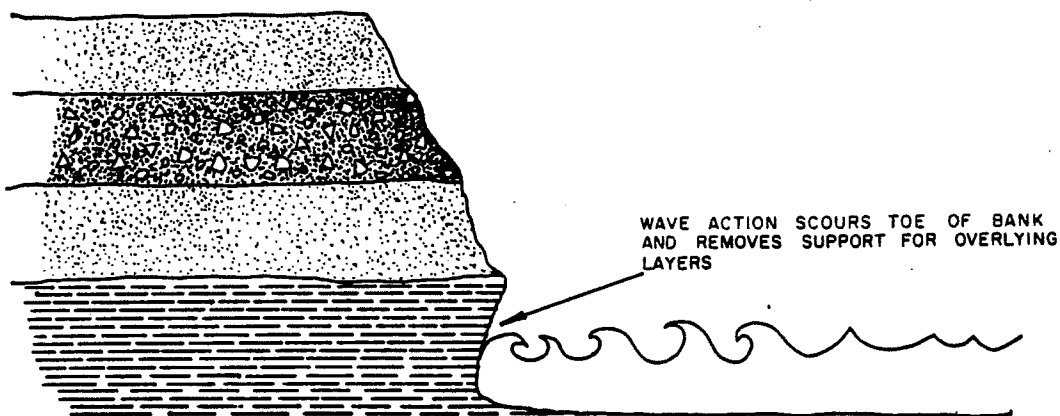
2.2 SHORELINE PROCESSES

Shoreline hazards result from the interaction of a complex system of physical processes. A number of individual processes are involved which act above, below and at lake level. The rates at which shorelines erode can vary tremendously depending upon the natural forces present as well as the impact of man-made structures. The following is a description of basic shoreline processes as they affect the shoreline under the jurisdiction of the Authority.

2.2.1 Wave Action

The principal cause of erosion in the area under the Authority's jurisdiction is wave attack. Waves impinging on the shoreline under storm conditions have sufficient energy to take large volumes of material into suspension. Once the material is in suspension it can be carried parallel to the shoreline or offshore into deeper water, depending on current patterns at the time. Material moved in this manner is known as littoral drift. The amount of wave energy which reaches the shoreline is dependent upon a number of factors, including the wave height, wave length, wave period, underwater topography, and shoreline configuration. Waves striking the shoreline at an angle other than 90 degrees result in longshore currents being established. Generally, the longshore currents carry coarse sediments parallel to the shoreline while finer sediments remain in suspension longer and usually are deposited in deep water offshore. Littoral transport is important to the replenishment of beaches. Material can be transported in either direction depending upon the direction of wave attack under a particular storm condition. In the Toronto area the most severe storm conditions are generated by either southwesterly winds or southeasterly winds. Although the southeasterly storms are generally not as common as the southwesterly storms, they do result in more energy reaching the shoreline. As a result, in most areas the net transport of material is to the west.

Waves acting on high bluff shorelines can undercut the slope by removing large volumes of material at the base of the slope, thereby eliminating support for overlying layers and causing bank failure. Talus material which may have accumulated at the base of the bluff can also be removed during periods of wave attack (Figure 3).



EFFECT OF WAVE UNDERCUTTING

FIG.3

Figure 4 shows the wind rose and a wave rose for the Toronto area, showing the predominance of southeasterly and southwesterly storms. Southeasterly storms generally produce higher waves with longer periods which contain more energy. These waves are produced by strong easterly winds blowing across a lake surface (fetch) of 110 km. This southeasterly fetch compares to only 48 km in a southwesterly direction and therefore is responsible for producing higher waves containing more energy.

2.2.2 Lake Levels

Lake levels, because of their influence on the amount of wave energy reaching the shore, also have a considerable impact on the rates of shoreline erosion. During periods of high lake levels, the protection afforded by beaches and other structures is reduced, with the resulting effect of a higher loss of material from the shoreline. The normal annual fluctuation in lake levels in the Toronto area is approximately one metre, while the total range in lake level from peak highs to peak lows can be approximately two metres.

Variations in lake level can cause temporary flooding of shoreline lands which are normally above water. There are essentially two types of lake level variations. First of all, there is a long term variation in the lake levels as referred to above, which can result in temporary flooding of low-lying areas for periods up to a few months. For these periods, the low-lying areas are particularly susceptible to additional flooding due to wind setup or wave uprush. Wind setup is a short term increase in lake level resulting from a wind blowing over the lake surface in one direction for a number of hours, which causes a water surface tilt to be produced. The range of setup depends on the length of fetch and the water depth. These short term fluctuations in lake levels are particularly important when they are coincident with high lake levels in the system as a whole. Flooding of this nature is particularly important in the Authority's area of jurisdiction around Frenchman's Bay in Pickering and in the Pickering Beach area of Ajax (Figure 5).

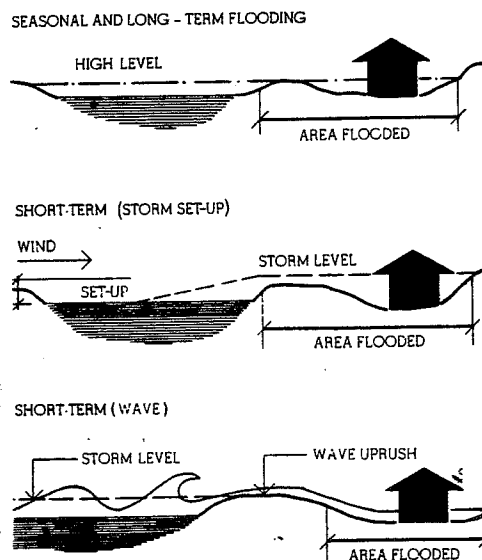
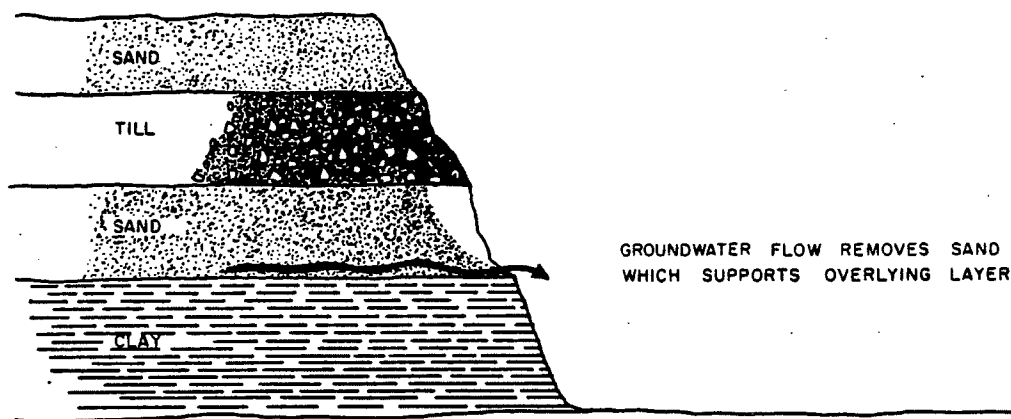


FIG. 5

2.2.3 Surface Erosion

Another important factor in shoreline erosion in the Toronto area, particularly along the high bluff shoreline in Scarborough, is surface erosion. Surface erosion generally occurs on slopes which are steeper than the natural angle of repose of the material and which are unable to support vegetative cover. It occurs because of the influence of rainfall and runoff as well as wind. Surface erosion can also be rapidly accelerated by groundwater seepage, as is frequently the case along Scarborough Bluffs. Surface erosion due to the influence of groundwater is particularly important in the high bluff shoreline which contains alternating layers of permeable and impermeable materials. The stratigraphy of the Scarborough Bluffs frequently contains a layer of sand over relatively impermeable clay or silty till material. The groundwater is confined in the sand layer until it reaches the face of the bluff, at which point it has sufficient velocity to carry away the sand material. As the sand layer is gradually deteriorated, the support for overlying layers is eliminated, resulting in surface sloughing of layers above the sand (Figure 6, Photo 9).

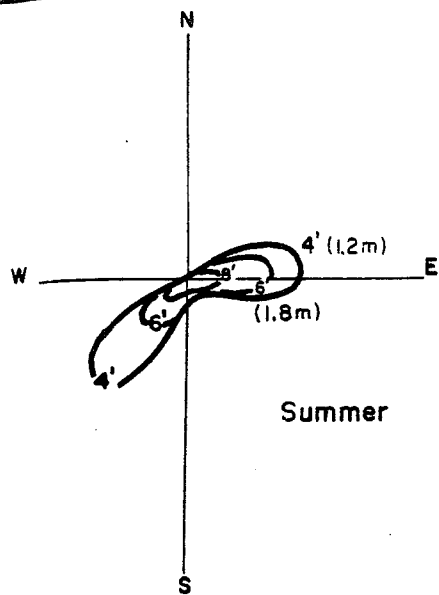


EFFECT OF SURFACE EROSION

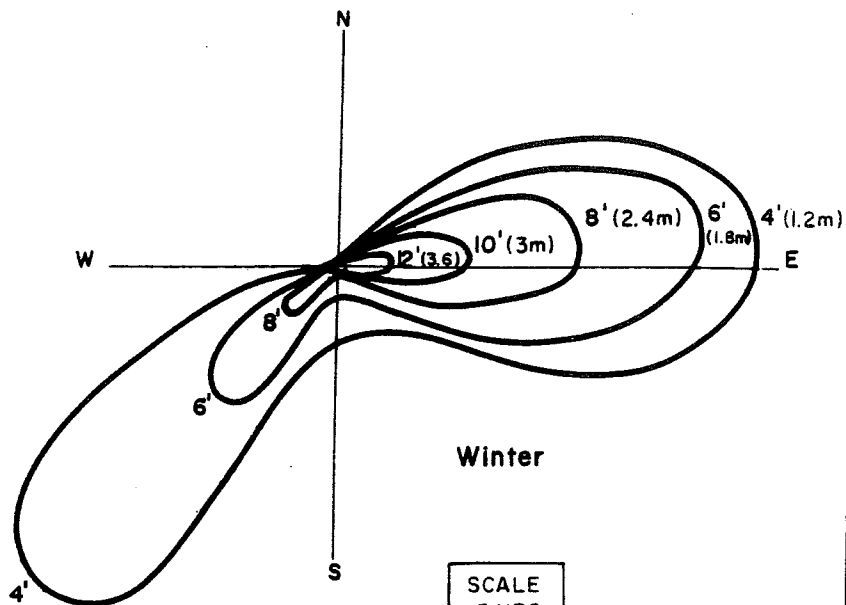
FIG. 6

2.2.4 Slumping

In some isolated areas of the Scarborough Bluffs, particularly along South Marine Drive, slumping is a significant erosion mechanism resulting in rapid loss of tableland. Slumping is a mass soil movement resulting from unstable bluff slopes. A bluff slope can become unstable in a number of ways. In the South Marine Drive location it appears that the bluff material has sufficiently low permeability that on some occasions the water content of the soil is elevated to the point that the soil loses its internal strength and slippage zones are created (Photo 10).



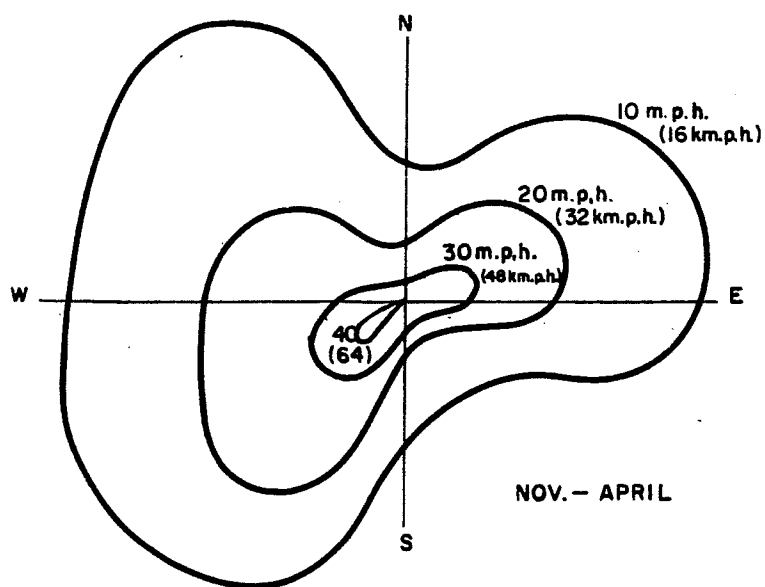
Summer



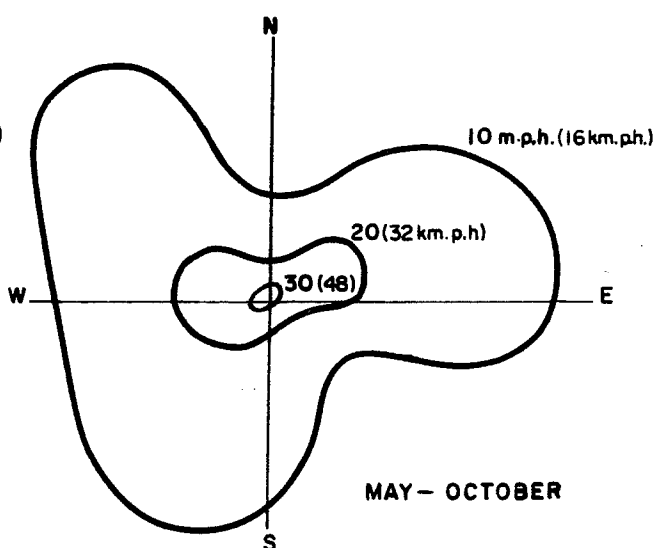
Winter

SCALE
5 HRS
SEASON

Significant Wave Roses
South of Toronto Islands
1948-1964 AVG.



NOV. - APRIL



MAY - OCTOBER

SCALE
110 HRS
1/2 yr.

TORONTO ISLAND AIRPORT WIND ROSES
1966-1971 AVG.



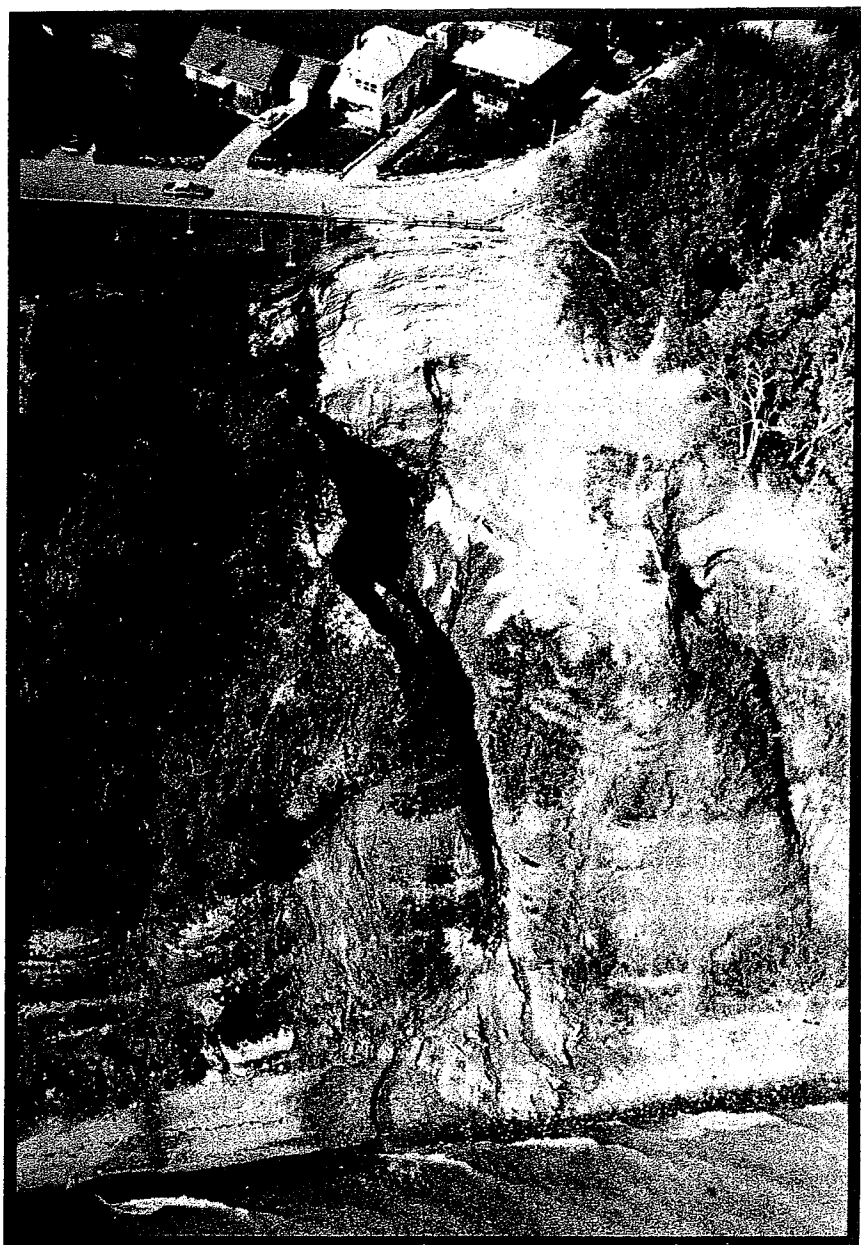
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TAKEN FROM TORONTO HARBOUR COMMISSIONERS,
DRAWING No. 15808, DATED APRIL 24, 1975

WATERSHED PLAN
SHORELINE MANAGEMENT PROGRAM

WINTER AND SUMMER
WAVE & WIND ROSES

FIG. 4



A HIGH FLOW OF GROUNDWATER EMERGING AT THE BLUFF
FACE NEAR KILDONAN DRIVE RESULTED IN A RECESSION
OF OVER 6 METRES IN ONE YEAR. (PHOTO 9)

2.2.5 Wind and Ice

Other secondary causes of erosion are wind and ice. The action of wind erosion is particularly important on sections of bluff with no vegetation and exposed sand layers. The fine sands, which are particularly common in the westerly end of the bluffs, are very susceptible to wind erosion. The process of ice jacking, which results from water flowing into narrow, open joints of a soil mass freezing and expanding, is particularly prevalent in the Needles section of the bluffs, just west of Bluffers Park.

2.2.6 Gully Erosion

Gully erosion is also a common mechanism which affects the shoreline configuration. Generally, gullies develop along shorelines where vegetation has been removed and development has occurred, accelerating surface runoff and confining it within certain channels. Over a period of time these channels enlarge, through continuous erosion, to form gullies of varying size, depending on bluff height and material. Along the Scarborough shoreline ravines of varying lengths have been created in this manner. The installation of comprehensive storm drainage systems has alleviated this problem, but in some instances the storm sewer systems have been outletted into these ravines, aggravating the problem and initiating bank failures.

2.3 ALTERNATIVE SHORELINE MANAGEMENT MEASURES

Shoreline Management is generally considered as the planning and implementation of measures intended to balance the actions of nature related to shoreline flooding and erosion with the demands of man for use of the shorelines for open space or intensive development.

The techniques of shoreline management may be subdivided into two categories: structural and non structural measures. Structural measures include revetments, breakwaters, groynes, seawalls, and artificial headlands and beaches for shoreline erosion control. These methods of controlling wave action can be combined with retaining walls, drainage measures, slope alterations and vegetation to control erosion on high banks. Non structural measures include the reservation of shoreline lands for recreation and open space uses, the regulation of shoreline use, emergency programs, shoreline damage reduction measures, and the acquisition of properties to enable the removal of endangered buildings. Structural measures tend to be more effective in areas where the shoreline has been urbanized while non structural measures are preventative, in that they are generally more effective in shoreline areas that have not yet been converted to flood or erosion-prone urban development but have the potential for such development.

2.3.1 Structural Measures

In view of the fact that the majority of the Metropolitan Toronto shoreline is highly developed, it is necessary to consider certain structural shoreline

protection measures to eliminate or reduce the rate at which valuable shoreline property is lost. Numerous types of shoreline protection structures can be used successfully depending on the physical characteristics of the particular section of shoreline and the amount of expenditure which can be justified to protect particular properties. The following is a brief description of a number of different shoreline protective measures which are commonly used.

(a) Seawalls

Seawalls are usually massive structures with a vertical face located at the interface between land and water. Seawalls are normally designed to prevent shore erosion by withstanding the full force of storm waves. They can be built from a variety of material ranging from timber to concrete to steel sheet piling. A common problem with seawall performance on exposed shoreline is the severe toe scouring which is induced by waves being deflected downward by the vertical face of the wall.

(b) Revetments

Revetments are sloped facings, usually of stone or concrete, used to stabilize the face of an embankment and resist wave attack by dissipating most of the energy through turbulence.

(c) Offshore Breakwaters

Offshore breakwaters are usually massive structures designed to resist the full impact of wave energy while allowing only minimal overtopping to occur. In the Toronto area offshore breakwaters consisting of rock-filled timber cribs have proven to be reliable, durable and efficient wave-absorbers along the exposed shoreline of Centre Island as well as along the Western Beaches. One of the disadvantages of offshore breakwaters is the usual requirement for construction by marine equipment, which normally results in a very high cost per unit of shoreline protected.

(d) Groynes

Groynes are shore protection structures frequently built as walls perpendicular to the shoreline. The primary function of a groyne is to trap littoral drift material and provide a wider than normal beach by providing additional protection to the adjacent shoreline. Groynes can be built with a rock core, of precast concrete sections, of grout-filled synthetic bags, of sheet steel piled walls, or in numerous other fashions. The spacing of groynes is generally expressed as a ratio to the groyne length. Ratios can vary from 3:1 to 1:1 depending upon the configuration of the shoreline, availability of littoral drift and other factors.

(e) Artificial Beaches

The concept of artificial beach construction is a variation of a typical groyne field construction. The construction of artificial beaches has become common in the Metropolitan Toronto region through the construction of landfilled recreational and harbour areas by the Toronto Harbour Commissioners and the Authority. The concept of artificial beaches and headlands requires that the alignment of the shoreline be such that the beaches created are at approximately a right angle to the net wave energy approach direction. By so aligning the beaches, the net loss of material out of the beach system is kept to a minimum. In areas where no natural nourishment is available to replenish these beaches, it is necessary to artificially nourish the partially contained unit. The containment of the beaches is accomplished by the construction of armoured hardpoints at either end of the beach which serve to anchor the beach material against seasonal shifts due to varying wave approach directions (Figure 7 and Photo 11).

2.3.2 Non Structural Measures

The use of non structural shoreline management measures is most applicable along stretches of shoreline where development has not yet occurred. Although virtually all of the shoreline under the jurisdiction of the Authority is developed, the principles of non structural measures should be applied to all redevelopment proposals as well as to the remaining undeveloped shoreline segments. One of the prime factors in developing a successful non structural management program is the accurate determination of the hazard zones resulting from shoreline flooding and erosion.

(a) Reservation of Shorelines for Open Space Uses

Comprehensive land use planning in an urban area recognizes the need for recreation and open space lands that are readily accessible to the residents. This premise is particularly important as it relates to the resource of the Lake Ontario shoreline. Provided that shoreline management objectives are met, the shoreline can be an ideal location for such lands and facilities and can be developed in such a manner while at the same time preserving the environmental amenities of the area. These open space objectives may be accomplished by several mechanisms including public acquisition by parks agencies or appropriate use of open space areas around major public facilities such as water supply plants or pollution control plants.

(b) Shoreline Regulations

Shoreline regulations are ordinarily intended for the single purpose of shoreline damage reduction by controlling the manner in which new development is carried out along the shoreline to ensure that it is neither flood-prone nor susceptible to erosion within the expected life of the structure. Regulations are also required to ensure that activities such as dumping of fill material do not affect the stability of the immediate area or adjacent properties. Long term

considerations must identify adequate setbacks which can be combined with structural shoreline protection to ensure that any new development or redevelopment occurs in areas where erosion or flooding will not cause a hazard.

(c) Emergency Programs

The loss of life, damage and disruption associated with shoreline flooding and erosion can often be minimized through a preplanned emergency program to be implemented when high lake levels and/or rapid erosion are impending or occurring. Warning of expected high lake levels of either a seasonal or short term duration can allow shoreline property owners sufficient time to install short term protection or vacate dwellings subject to flooding. Monitoring of erosion hazards can result in sufficient warnings being given to vacate endangered dwellings.

(d) Structure Removal

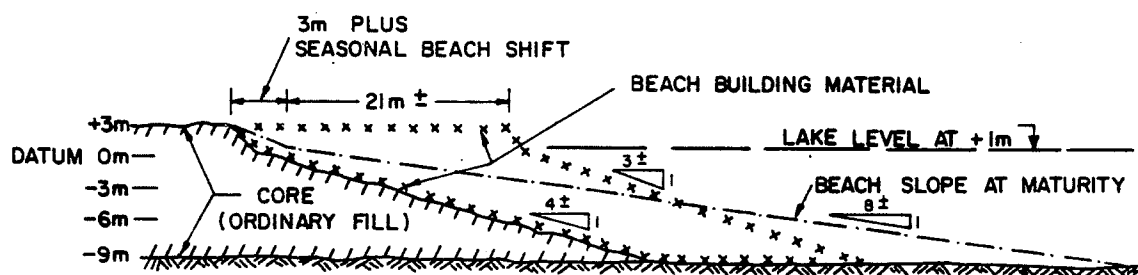
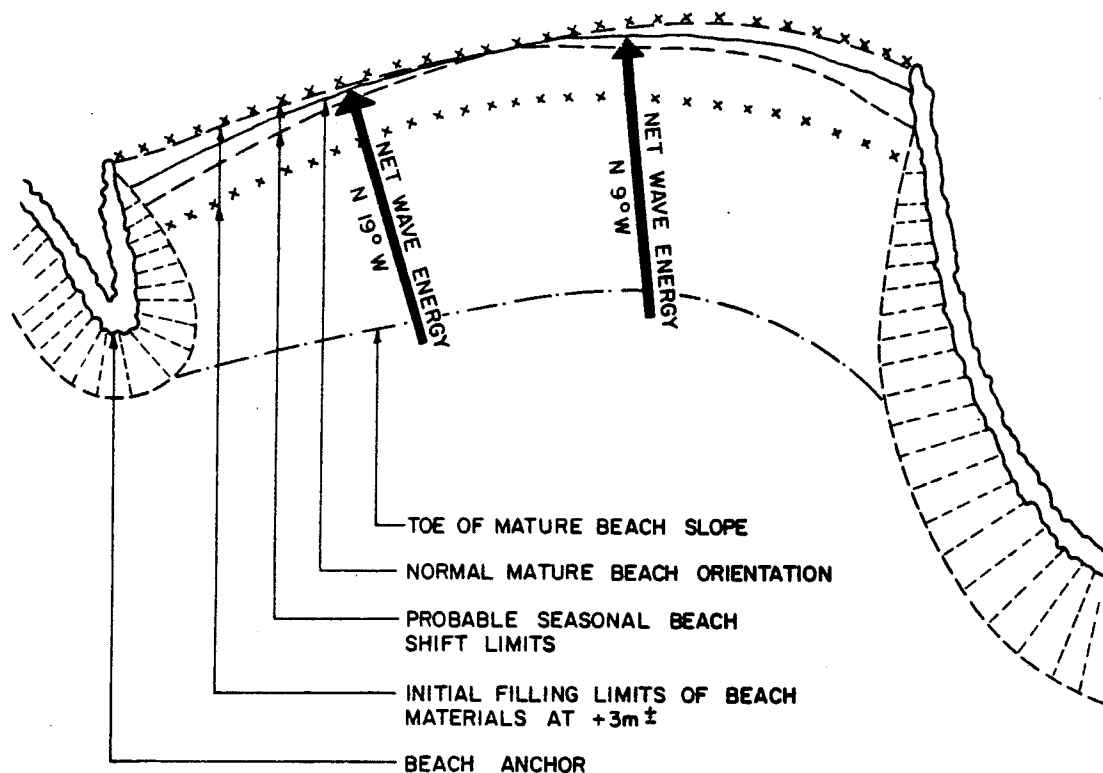
In many shoreline areas it is uneconomical to construct shoreline protection measures because of low benefit to cost ratio. In these cases, it may be reasonable to acquire the susceptible structures and remove them from the flood and erosion-prone areas. The cost of removing a residential structure is generally considered to be the sum of the structural acquisition cost, demolition and the restoration costs. The use of this alternative must be considered carefully and weighed against the loss of tax base and the general impact on the community of removing dwellings rather than constructing protective works.

2.4 INITIATIVES OF OTHER AGENCIES

It was previously noted that the problem of shoreline erosion and flooding is common to virtually all of the shoreline of the lower Great Lakes. Therefore, numerous agencies have become involved in the study of appropriate shoreline management programs. A joint effort by Fisheries and Oceans Canada and the Ontario Ministry of Natural Resources produced the Canada-Ontario Shore Damage Survey. This document identified that in 1972 to 1973 the lower Great Lakes shorelines sustained flood and erosion damages amounting to \$28 million. As a result of the survey, the Federal-Provincial team proceeded to map the 100 year erosion limit, based on long term erosion rates, and areas that have a 1% chance of flooding in any one year, for the entire shoreline extending from the Sauble River on Lake Huron to Gananoque on Lake Ontario. In addition to the mapping program, erosion monitoring at 162 selected erosion sites on Lakes Ontario, Erie, St. Clair and Huron and on Georgian Bay was initiated.

Following the high water period of 1973 the Government of Ontario through the Ministry of Natural Resources made funding available through the Shoreline Property Assistance Act to enable private property owners to undertake shoreline protective works with the benefit of low interest loans.

In addition to the Federal and Provincial initiatives, many of the Conservation Authorities having shoreline jurisdictions have undertaken to prepare shoreline



TYPICAL PROFILE

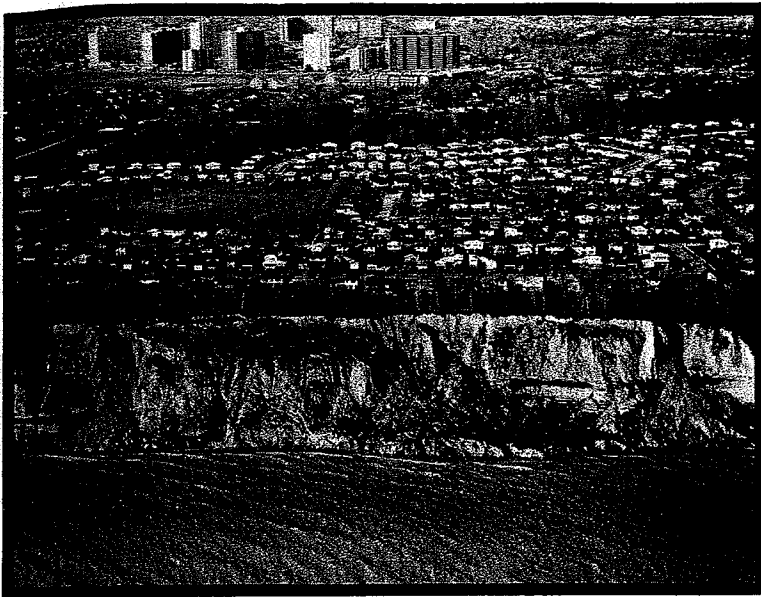


the metropolitan toronto and region
conservation authority

WATERSHED PLAN
SHORELINE MANAGEMENT PROGRAM

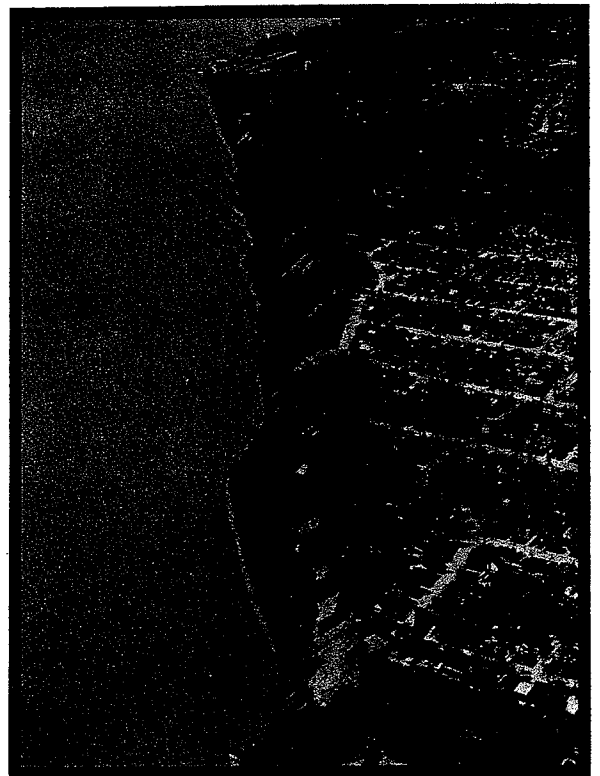
BASIC DESIGN FEATURES OF
AN ANCHORED BEACH

FIG. 7



THE SHORELINE ADJACENT TO SOUTH MARINE DRIVE IS AFFECTED BY MASSIVE SLUMPING. THE SETBACK ZONE WHICH WAS ESTABLISHED AT THE TIME OF DEVELOPMENT HAS BEEN LOST TO EROSION IN SEVERAL LOCATIONS. (PHOTO 10)

THE DEVELOPMENT PATTERN ALONG THE BLUFFS RESULTED IN MANY STREETS PARALLELLING THE CREST WHICH IS SIGNIFICANT BECAUSE MANY HOUSES WILL BECOME ENDANGERED AT APPROXIMATELY THE SAME TIME IF EROSION CONTINUES. (PHOTO 12)



THE ARTIFICIAL HEADLAND AND BEACH CONCEPT OF SHORELINE PROTECTION WAS EMPLOYED AT THE EASTERN BEACHES WHERE ARMoured HEADLANDS ANCHOR PROTECTIVE SAND BEACHES. (PHOTO 11)



management programs to deal with erosion hazards.

The problems of shoreline erosion and flooding are not confined to the Canadian shorelines of the Great Lakes. The government of the United States has initiated a Coastal Zone Management Program for all its shorelines including the Great Lakes. One objective of the American program is to address the ever increasing cost of damage along the Great Lakes shorelines by developing zoning restrictions to control urbanization and to construct protective works to reduce or eliminate damage to existing structures. The American program goes beyond considerations of shoreline flooding and erosion to deal with questions of land use in general, including energy plant siting, public access, port-related facilities and environmental concerns.

The U. S. Army Corps of Engineers is one of the world's leading agencies in development of coastal engineering technology and shore protection techniques. Numerous publications have been released by the Corps which describe appropriate shoreline erosion control works for the Great Lakes.

3. PROBLEMS AND IMPLICATIONS

It has previously been noted that the shoreline under the jurisdiction of the Authority varies widely in its physical characteristics. As a result, the type and seriousness of the potential hazards also vary.

In general, the shoreline in the Etobicoke sector has been adequately protected by private property owners. Erosion and flooding only occur during abnormally high lake levels. There are no locations where homes are endangered or lives are threatened, but the property owners must be prepared to repair or replace their shoreline protection after certain extreme events.

As noted earlier, the control of shoreline hazards within the City of Toronto sector is dependent primarily on the maintenance of existing shoreline protective structures. For example, along the Western Beaches the existing offshore breakwater will require increasing amounts of maintenance in the future in order to ensure adequate protection for this valuable park space. In addition to this requirement, the retention of the popular park space between Lee Avenue and Nursewood Road relies on maintenance of the existing groyne system. The one area within the City of Toronto sector requiring new shoreline protection is Gibraltar Point on the Toronto Islands. At this location land is being lost at the rate of over a metre per year and a public building, as well as the CKEY radio towers, is threatened. As described in the Background section, the exterior shoreline of Aquatic Park requires final protection, much of which will be provided by the construction of the containment dyke for the dredge disposal area.

It is in the Scarborough section where the most serious hazards exist. The long term average erosion rates of .5 m to .7 m per year have gradually reduced the minimal building setbacks which were established at the time of initial development of the shoreline. As a result, serious threats to houses and municipal servicing existed at several locations over the period 1977 to 1979. The Authority acquired four properties which were no longer safe dwellings, while the Borough of Scarborough was forced to carry out emergency filling programs to save roads and servicing in two locations.

Erosion continuing at its present rate will result in similar situations developing at an ever increasing rate in the future. One analysis has shown that if current erosion rates continue for another 75 years there is a potential for loss of approximately 150 houses, as well as 20.2 ha of private lands across the Scarborough shoreline. In addition, municipal servicing will be lost at two locations and approximately 10.1 ha of public land will be lost.

Although only five houses were removed over the period 1977 to 1980, the number of houses which will become endangered is expected to increase rapidly as a result of development patterns. Many of the areas along Scarborough Bluffs are developed with long streets which parallel the bluffs. A large number of houses, therefore, back directly onto the bluffs and as bluff recession continues, these

houses will become threatened at approximately the same time. Another key factor to consider is that some houses cannot be saved even if protection is installed immediately. If protection is not installed immediately the number of houses that will not be saved by protection in the future will rise dramatically as the bluffs recede towards these rows of houses which parallel the bluff crest (Photo 12).

Added to the physical losses mentioned above are the social impacts on the existing residential neighbourhoods due to a long term hazard of this type. The spectacular vistas available from the residential dwellings in the neighbourhoods located along the top of the bluffs continually attract prospective home buyers. Unfortunately, many home buyers do not become fully aware of the potential hazard until after the purchase has been completed and, therefore, there is a relatively high rate of sale of housing, leading to unstable neighbourhoods.

The long term erosion rates along the Scarborough shoreline were established by a study carried out over the period 1922 to 1952. This study measured average rates of between .5 m to .7 m per year for recession of the crest of the bluff. Although these rates are generally accurate, they can also be misleading. In some areas, natural variation in groundwater flow has resulted in dramatically increased rates of bluff crest recession. For example, in the Crescentwood Road area at the foot of Kildonan Drive the crest moved inland by more than 6.1 m in the one year period from 1976 to 1977. Only an emergency program of dumping of concrete rubble from the top of the bluff saved the road and major arterial services located in the road allowance.

A similar situation occurred at the corner of Kingsbury Crescent and Harding Boulevard resulting in three houses becoming endangered and subsequently requiring their purchase and removal by the Authority. Again, only a massive filling program carried out by the Scarborough Works Department saved the road and servicing and delayed the requirement for removal of other houses. In both cases a serious hazard developed in a very short time period after lengthy periods of average recession rates. It is not unreasonable to assume that similar situations caused by concentrations of groundwater flow will result in future hazards at other locations.

The shoreline erosion hazards along the Scarborough Bluffs are among the most dramatic in the lower Great Lakes. The erosion results from an interaction of complex geological processes which will not be controlled by individual private property owners. A comprehensive Shoreline Management Program is required for the entire length of this spectacular geological formation.

In the Pickering/Ajax sector many of the potentially hazardous situations resulting from flooding have been eliminated by the Authority's Acquisition Program. However, some areas of the Frenchman's Bay spits, as well as the Pickering Beach area in Ajax, are still susceptible to flooding during extreme events and these potentially endangered dwellings should be acquired and removed.

Fortunately most of the potential hazards to erosion in the Pickering/Ajax sector were avoided by acquisition of a shoreline strip by the Authority before residential development took place. Shoreline management decisions in this sector must achieve a balance among the capital costs of protection, the desire for a natural shoreline configuration and adequate protection of a significant shoreline land base which was acquired at a cost of approximately \$7,000,000. Adequate protection of this significant shoreline strip is extremely important.

Significant sections of the shoreline in Pickering and Ajax are under the control of other public agencies which perform vital functions. For example, the Ontario Hydro lands east of Frenchman's Bay, which contain the Pickering Nuclear Generating Station, must be protected. Similarly, the sites of municipal water filtration plants and the major sewage treatment facility constructed by the Ministry of the Environment west of Duffin Creek will require shoreline stabilization to avoid long term loss of the essential facilities.

4. POLICY

Shoreline management is an essential component of any comprehensive waterfront program. In the same way that modifications to the valleys must be part of an integrated water management system, so must shoreline modifications form part of an overall shoreline management policy. The degree of integration which can be achieved will have a direct bearing on the quality of the resultant shoreline. The waterfront in the region under the Authority's jurisdiction is already largely developed; thus, controls on land use will not have a significant short term benefit. However, over the longer term, when redevelopment occurs, there is greater potential for significant improvement.

In the short term, shoreline management means minimizing the loss of property due to flooding and/or erosion along the developed shoreline. The social, environmental, and economic disruption caused by erosion is considered too great to allow it to continue unmitigated. In this regard the Authority has established the following goal for its Shoreline Management Program:

TO UNDERTAKE A COMPREHENSIVE PROGRAM OF SHORELINE
MANAGEMENT DESIGNED TO PREVENT, ELIMINATE, OR
REDUCE THE RISK OF HAZARD TO LIFE AND PROPERTY,
WHILE COGNIZANT OF THE NATURAL ATTRIBUTES OF THE
LAKEFRONT SETTING.

In order to achieve this goal it is the objective of the Authority to:

- (a) seek the cooperation of municipalities in preventing the creation of new hazard prone development through the incorporation of appropriate statements and designations concerning hazard areas in Official Plans and secondary plans (or their equivalent), and, to ultimately control development in such hazard areas through the enactment of restricted area bylaws (zoning) and/or development control bylaws;
- (b) cooperate with all agencies concerned with improving the water quality of Lake Ontario in the area under the jurisdiction of the Authority;
- (c) carry out works along the shoreline of Lake Ontario in accordance with proper shoreline management principles. Works will primarily be of a type and design which will form a part of an integrated management system for the entire shoreline; will limit abnormal erosion at the land/water interface, will enable public access along the water's edge, and will be conducive to beach maintenance;
- (d) cooperate, where possible, with municipalities, other government agencies and private owners in establishing criteria for their shoreline works which will be consistent with the Authority's shoreline management policy.

The Authority recognizes the need for a comprehensive shoreline management program directed at reducing shoreline erosion and diminishing the need for emergency programs which, in the past, have been necessary at the extreme of lake level fluctuations. The Program provides for a comprehensive shoreline management strategy that will regulate development within the defined hazard zone, publicly acquire those waterfront lands which are hazardous, and limit erosion at the land/water interface. In this regard the Authority will operate in accordance with the following principles:

- (a) to prevent the occurrence of further erosion and flood damage, the Authority will apply regulations made under The Conservation Authorities Act to control filling and construction in designated hazard areas;
- (b) to recognize the suitability of acquiring certain waterfront hazard land, which due to its physical characteristics (low-lying beach and marsh areas, and other areas subject to rapid erosion or flooding) is undesirable for development. The acquisition of such hazard lands is more fully addressed in the Land Acquisition Program;
- (c) subject to the Authority obtaining title or easement to required shoreline areas, and subject to the areas being of sufficient size to be physically and economically feasible, to carry out shoreline protective works which can form part of an integrated management system for the entire shoreline.

5. PROGRAM DETAILS

The Shoreline Management Program is composed of two major components: Prevention and Protection.

5.1 PREVENTION COMPONENT

In order to be fully effective, the Shoreline Management Program must endeavour to prevent future problems in addition to rectifying existing ones. Although virtually all of the shoreline under the jurisdiction of the Authority can be considered 'developed', infilling pressures and redevelopment proposals do exist and should be controlled to ensure that shoreline hazards are not created.

5.1.1 Rationale

Shoreline hazards are not always initially apparent. For example, long periods of low lake levels can cause developers and prospective home purchasers to forget the potential hazards that exist during higher lake level conditions. High bluff shorelines can also appear quite stable during summer periods when annual vegetation can hide some of the serious underlying instabilities.

Although shorelines can be stable for several decades, natural variations in groundwater flow, availability of beach nourishment material or other factors can create serious instability in a relatively short period of time. Development control measures in particular must allow a sufficient buffer to compensate for these long term potential hazards.

The prevention component must also deal with the implications of one shoreline development as they affect another. For example, some shoreline management techniques can have a serious impact on adjoining properties. Potential developments must, therefore, be reviewed to examine the probable success of the works as well as to identify any potential impacts on other properties. While some protection techniques provide an apparent short term benefit, they may in fact worsen the long term condition to the detriment of a much longer section of shoreline.

The prevention component must deal with a particular resource. Development or redevelopment, as it is affected by flooding or erosion, must be reviewed in the context of the shoreline system which, in many cases, transcends municipal boundaries.

If prevention measures aimed at minimizing potential hazards of shoreline flooding and erosion are not instituted, then protective works must continue to be undertaken at ever increasing costs. The cost of rectifying past actions and problems presently necessitates the establishment of work programs in the millions of dollars. With cooperation between the municipalities and the Authority, the preparation and enforcement of development control measures, and the dissemination of information on wise land use practices, the present Requirement

for high investment in protective works will not continue indefinitely. However, as noted previously and as described in detail in a subsequent section of this report, there is an urgent need for remedial measures to be undertaken along substantial lengths of the Authority's jurisdiction.

The Metropolitan Toronto and Region Conservation Authority has concluded that there is justification for government involvement in the protection of private and public property from shoreline erosion and flooding. Further, there is justification for the involvement of the Conservation Authority in providing the required assistance because it brings together the two government levels involved in land use planning: the municipality and the Province of Ontario. The Authority has extensive experience in managing the other resources of the region, particularly the valley systems, which involve similar problems, and therefore is the logical choice as the agency to implement a shoreline management program.

5.1.2 Program Direction

The implications of continued shoreline development were made more apparent during the high water period of 1973. If an active prevention program is not implemented, the resulting problems will become increasingly evident as pressure for infilling and redevelopment of the attractive shoreline area is increased.

The success of any prevention program requires the cooperation and working endorsement of the Authority, its member municipalities and other appropriate government agencies.

Municipal zoning and land use controls should recognize the existence of hazards and provide adequate setbacks for new development or redevelopment. In some areas it may be possible to combine requirements for setbacks with a program for construction and maintenance of appropriate shoreline protective structures.

A successful prevention component must also provide assistance to private owners in their attempts to design shoreline protection. This assistance is imperative to improve the standard and success rate of private shoreline protection while minimizing the impacts on adjacent shorelines.

The prevention component must also provide for regular patrols and monitoring of potential serious hazards to ensure that endangered dwellings are vacated. Similarly, the patrol function must ensure that construction practices or illegal dumping of material are not creating new hazardous situations.

The success of any prevention program is dependent in part on making the public aware of existing hazards and problems and how such hazards and problems are created. Information programs should be prepared which include suggestions on wise land use practices which minimize the creation of erosion problems.

5.1.3. Operational Criteria

Shoreline erosion and flooding-related problems can be minimized through the institution of the following criteria:

- (a) Buildings, structures, or additions, (including paved surfaces), whether situated above or below ground level, should not be permitted in the following hazard impact zones, unless studies by a competent professional show that the buildings, structures, or additions will be safe during their life, which for Authority purposes is 100 years; and that the buildings, structures or additions will not aggravate existing or create additional problems:
 - 10 metres back from the 100 year wave uprush line as determined by the Great Lakes Flood and Erosion-Prone Area Mapping where no definable bank exists; or
 - 10 metres back from the estimated 100 year erosion limit or if such information is not available, 10 metres back from the anticipated 2:1V slope for unprotected eroding shorelines; or,
 - 10 metres back from a stable bank (for Authority purposes assumed to be 2H:1V slope).
- (b) Surface drainage from any building, structure or paved surface should not be permitted to be discharged over shore cliffs. Such surface drainage should be directed away from the face of the shore cliff or, where appropriate, piped to the base of the cliff.

5.2. PROTECTION COMPONENT

The protection component of this Program is intended to protect lives and minimize loss of property and municipal servicing. The Program proposes the construction of suitable shoreline protection works to minimize long term losses and to save as many homes as possible. Those homes which become endangered and cannot feasibly be protected by structural means will be acquired in accordance with the policies established in the Authority's Land Acquisition Program. Similarly, those areas which are subject to flooding during periods of high lake levels will also be acquired in accordance with the Master Plan for Acquisition.

5.2.1. Rationale

Previous sections of this Program have established that significant amounts of very valuable waterfront land are being lost and that an ever increasing number of residential dwellings are becoming endangered. At the same time, municipal servicing systems and road networks which affect larger areas of developed communities are also threatened. As noted in the description and history of the Scarborough shoreline, it is apparent that the scope of the problem is far beyond the capabilities of private property owners. A comprehensive program of protection of high priority areas could be carried out by the Authority to deal with these problems and, at the same time, establish public access along the shoreline.

If a comprehensive program of shore protection is not undertaken, there will be increasing social pressure for short term emergency public action which can be more expensive in the long term and will not have the benefit of a comprehensive approach.

5.2.2 Program Direction

Shoreline protection to limit erosion at the land/water interface will be carried out on the basis of technical priorities within the limits imposed by the allocated funding and the availability of access. It is apparent that wave action is the principal cause of long term shoreline instability. Although in areas of high bluff shorelines where toe protection is constructed the bank will continue to recede, it is imperative to establish a firm line of toe protection in order to ensure that recession at the cliff crest can ultimately be stopped.

The slope processes themselves are important factors which must be taken into account in the design of the toe protection. The location selected for the toe protection must be such that maximum advantage can be taken of the accumulation of talus material which can be expected when the influence of wave action is controlled. The talus formations can be expected to be very unstable in most locations due to high water content and measures to drain the talus may be required. Care must be taken to ensure that talus buildup against the bluff face does not significantly alter the failure mechanism of the bluff.

In some areas of the bluffs, houses are so close to the bluff that they cannot be saved by toe protection alone. Certain areas are threatened to the point that even a combination of toe protection and bank stabilization will not save the dwelling.

In areas where toe protection must be combined with bank stabilization to save valuable property, it may be possible to incorporate drainage techniques which would help to retain the natural strength of the bluff material. Drainage measures could consist of vertical or horizontal well points, vertical drains, horizontal drains, groundwater cutoff walls or other positive drainage systems which would convey most of the groundwater to the shoreline in a controlled manner. The cost of these drainage works would be weighed against the value of the property to be protected in order that a decision could be made on whether or not the bluff should be allowed to recede following the removal of endangered dwellings or services.

Properties which cannot be protected structurally against erosion at reasonable cost will be acquired as described in the Authority's Land Acquisition Program. Similarly, areas which are vulnerable during periods of high lake levels will be acquired within the Authority's Master Plan for Land Acquisition on the Waterfront.

The sites of highest priority for shoreline protection are in almost all cases located within the Borough of Scarborough. The Authority would, therefore, be attempting to establish a comprehensive system of shoreline protection along the base of Scarborough Bluffs from the Fallingbrook area to East Point Park, as well as dealing with the erosion of Gibraltar Point on Toronto Islands and any serious problems in Etobicoke, Pickering and Ajax. The details of the various sites to be treated will be identified within the Authority's subsequent

project documents. It is the intention of the Authority, within the limits of funding, to protect the most seriously affected areas within the Authority's jurisdiction by 1992. Figure 8 indicates the general priorities for protective works and identifies potential construction access points along the Scarborough shoreline.

The Authority has directed numerous studies to establish the nature of the shoreline hazards and to develop strategies for shoreline protection. The Erosion Control Study (1976) was a complete inventory of shoreline conditions across the entire length of the Authority's jurisdiction. This study identified potential losses due to erosion and recommended remedial measures to minimize these losses. The report, prepared by Authority staff, also indicated the general priorities for protective works.

The potential for use of artificial headlands and beaches for shoreline protection in Scarborough was examined in a report prepared for the Authority by the Toronto Harbour Commissioners. This analysis, entitled "Feasibility Study of Artificial Beach Stabilization of the Scarborough Bluffs", produced preliminary design shapes for new beach systems to protect the toe of the bluffs.

Detailed investigations of the engineering properties of the bluff materials were undertaken by Geocon (1975) Ltd. The Authority initiated this analysis to determine the impact of toe protection on the behaviour of the bluff face. It is important to identify the slope retrogression which will occur following shoreline protection as this is essential in defining potential losses over the long term. These losses must be quantified for use in cost/benefit analyses of the shore protection works.

The works which were undertaken at Crescentwood Park in 1979 were the subject of a staff report on the design of the armour stone revetment and groundwater control measures which were installed.

The use of vegetation as a means of controlling surface erosion was investigated for the Authority by J. C. Taylor and R. S. Hilton of the University of Guelph in 1973. Vegetation studies were also undertaken by Gwynneth Collishaw, M. C. Lewis and C. D. Fowle of York University in 1978.

The studies briefly outlined above, as well as other detailed investigations, have been used to formulate this Program. More information will become available as the implementation of the Program proceeds and additional detailed investigations will be required for input to the Authority's project documents. However, the available information is sufficient to identify many of the Program details.

Protective measures will, wherever possible, provide beach configurations. Beach forms are among the most effective shoreline features in terms of wave energy dissipation, as well as being aesthetically pleasing and conducive to safe public access. For example, the shoreline protection plan for the Scarborough shoreline will rely heavily on a system of artificial beaches and

headlands. This system will involve the construction of numerous beach segments aligned at right angles to the net wave energy approach direction. As the alignment of these segments is affected by factors such as existing shoreline configuration and bathymetry, exposure to wave action, size of beach material and numerous other considerations, it is apparent that the segments will vary considerably across the Scarborough sector.

These beach units will become an important feature of this spectacular landscape and must be appropriately designed and constructed. Every effort will be made to maximize the public use of these new shoreline features for recreational purposes.

One of the key considerations in the design of appropriate shore protection, particularly in Scarborough, is construction access. The physical barrier of the high bluffs restricts land based access while marine access generally results in high costs. The revetment which was built at Crescentwood Park in 1979 relied on a combination of both modes of transport. The materials were brought to the site by land while the equipment required to transport and place the material along the shoreline was brought to the site by barge. It appears that the shoreline between Warden and Birchmount requiring immediate attention will be protected in a similar fashion.

Implementation of the broad Program for shoreline management in Scarborough will require other points of access. For example, the possibility exists to create a new vehicular access point to the shoreline at Bluffers West, near the intersection of Kingston Road and Glen Everest. This access would require regrading of the bluffs east of Lakehurst Crescent through lands acquired by the Authority immediately west of Rosetta McClain Gardens. This construction would eliminate the development of this area for park purposes and, therefore, careful studies must assess the feasibility of protecting this critical section of shoreline by access from Bluffers Park or alternatively by dumping of materials from the top of the bluff in isolated areas, as was done at Crescentwood Road. The Bluffers Park access will be useful in construction of shoreline protection for a distance west of the park, perhaps as far as Lakehurst Crescent. Access can also be developed easterly from Bluffers Park as far as Sylvan Park. The shoreline access at the Guild Inn has the potential to service the area westerly to Sylvan Park and easterly to Morningside Avenue. East Point Park provides an opportunity to reach the remaining eastern areas of critical erosion. Figure 8 summarizes the potential access points which are vital to successful completion of the Authority's program.

5.2.3 Operational Criteria

Implementation of the protection component of the Shoreline Management Program involves the application of certain operational criteria. The criteria are intended as a guide for Authority involvement; however, exceptions may be required under some circumstances. The criteria are:

- (a) The major emphasis in the undertaking of protective works will be to control erosion due to wave action. The required works will be designed in consideration of maximum expected lake levels as well as peak storm conditions.
- (b) Consideration will be given to bank stabilization techniques to be combined with toe protection in areas where additional protection is required to retain slopes at steeper than natural angles.
- (c) Shore protection will be carried out on a design block basis. Design blocks are shoreline segments with physical characteristics which permit the segment to be protected as a unit. The characteristics to be considered include shoreline configuration, construction access, bank condition talus formations and wave energy climate, among others.
- (d) Shoreline protection will be installed on a technical priority basis related to the safety of property and structures within the limitations of funding, approvals, construction access and property acquisition. Priorities shall be based on technical criteria including, but not necessarily limited, to the following:
 - distance from top of bank to structure
 - rate of slope retreat
 - extent of groundwater seepage
 - height and steepness of slope
 - soil composition
 - vegetative cover, type and extent
 - evidence of previous movement
 - condition of toe of slope
- (e) Priorities for protection will be reviewed and approved by the Authority on an annual basis.
- (f) Existing waterfront public lands provide valuable recreational opportunities and, in many cases, serve as buffer zones between the shoreline and private lands. Therefore, the balance between funding allocated for protection of public and private lands is an important relationship which should be approved annually by the Authority.
- (g) In cases where private property is involved, the Authority shall require title to the land for a nominal sum or an easement where applicable, and in addition may require a suitable financial contribution from the benefiting owner(s).
- (h) The Authority will assist in developing technology and distributing information which will aid property owners in limiting the erosion of the bank after the toe protection is installed.

- (i) The Authority's nursery will grow and sell plant material which is particularly well suited to bank stabilization and is not readily available from commercial suppliers. This part of the Program will be administered in accordance with The Conservation Land Management Program.
- (j) The protection and shoreline maintenance of all future park developments should be considered as part of the capital development cost and not be funded from the shoreline management allocation. However, the maintenance of existing and proposed Authority waterfront recreational lands should be funded within the Shoreline Management Program.

5.3 ENVIRONMENTAL IMPLICATIONS OF SHORELINE MODIFICATION

Environmental impacts to both the terrestrial and aquatic environment can occur as a result of shoreline modifications. In the short term most of the impacts will be of a negative nature but in the long term some positive impacts will occur. The following discussion is an attempt to identify some of the potential impacts of shoreline modification, especially along the Scarborough Bluffs, so that any impacts can be minimized through sound environmental planning and construction practice.

5.3.1 Aquatic Environment

Shoreline erosion contributes large quantities of sediment to the nearshore zone of Lake Ontario. Fricsberg (1970) estimated that approximately 300,000 m³ of material is lost to the lake each year from the Scarborough Bluffs alone. Most of this material is eventually deposited in deeper water, but, because the input is continuous, eroded material is always present in the nearshore zone of the lake. The finer fraction of the eroded material remains in suspension, contributing to high turbidity levels in the water. Coarser fractions, such as silt, are resuspended during storms and tend to further aggravate the turbidity problem. Not only is turbid water aesthetically displeasing but it can be detrimental to aquatic organisms if present at sufficiently high levels. The deposited component of the eroded material can also be detrimental to aquatic life, especially to fish during the critical spawning period.

In the short term it is expected that sediment loss to the lake will increase due to filling, grading and armouring; however, shortly after the works are completed sediment loss to the lake will decline greatly. In the long term, longshore turbidity and sediment deposition should decline considerably to the benefit of the aquatic environment.

A potential permanent impact to the aquatic environment is the loss of littoral zone when modifications extend beyond the present shoreline. However, the loss should be insignificant if filling does not extend beyond the surf zone (1 to 2 metre depth contour). This zone has a sparse fauna and is generally considered inconsequential to the overall ecology of the lake.

5.3.2 Terrestrial Environment

Potentially the greatest impact could occur to the terrestrial environment. The area where most of the work is scheduled to be carried out (Scarborough Bluffs) is one of the last natural corridors in the Authority's jurisdiction.

The practice of using construction vehicles, dumping both fill and armouring material over the bluffs and/or transporting it along the base of the bluffs, can cause soil erosion, soil compaction, changes in water flow patterns, defoliation and destruction of wildlife habitat. In addition, increased access to the base of the bluffs by both construction crews and the public, if not properly controlled, could cause a reduction of wildlife movement, essentially segregating what is presently one community spanning the entire section of the bluffs into a number of non interacting subcommunities.

The major concern with respect to the long term impact to the terrestrial environment relates to successional changes that will occur along stabilized sections of the bluffs. Presently a variety of successional plant communities are represented on the bluffs from bare slopes with little vegetation to hardwood forests. Stabilization of the slopes could, over time, result in the elimination of some of the earlier stages of succession; however, stabilized slopes would support individual communities of higher diversity. Since a detailed examination of the flora and fauna of the bluffs has not been carried out, the implications of such changes are not known.

5.3.3 Environmental Monitoring

Prior to any large scale shoreline modification, the Authority proposes to carry out a comprehensive program to determine the flora and fauna of the area, assess the potential impacts of the project on the environment, and, through environmentally sound planning and construction practices, minimize or eliminate many of the environmental impacts outlined above.

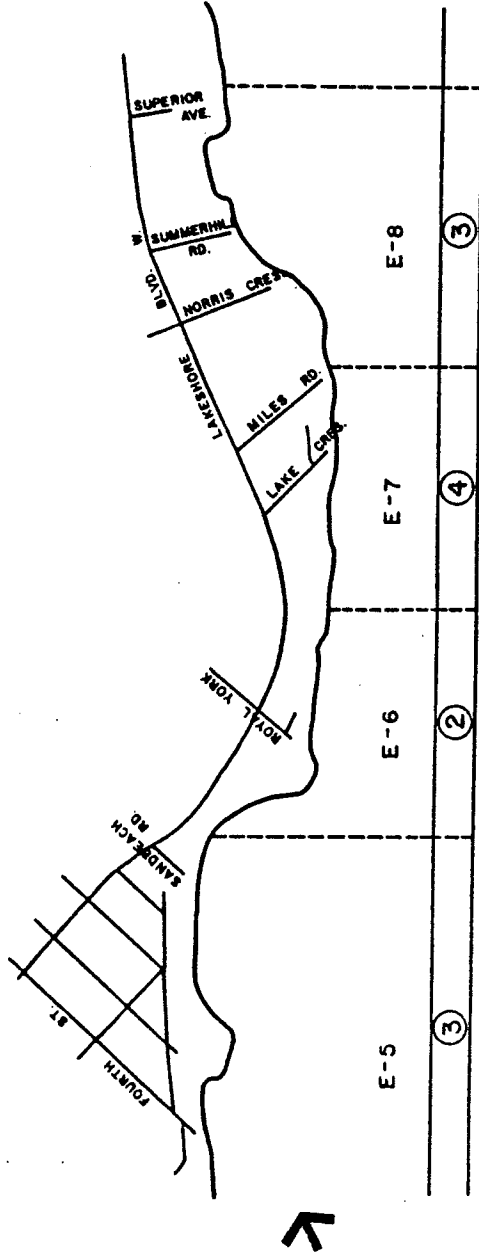
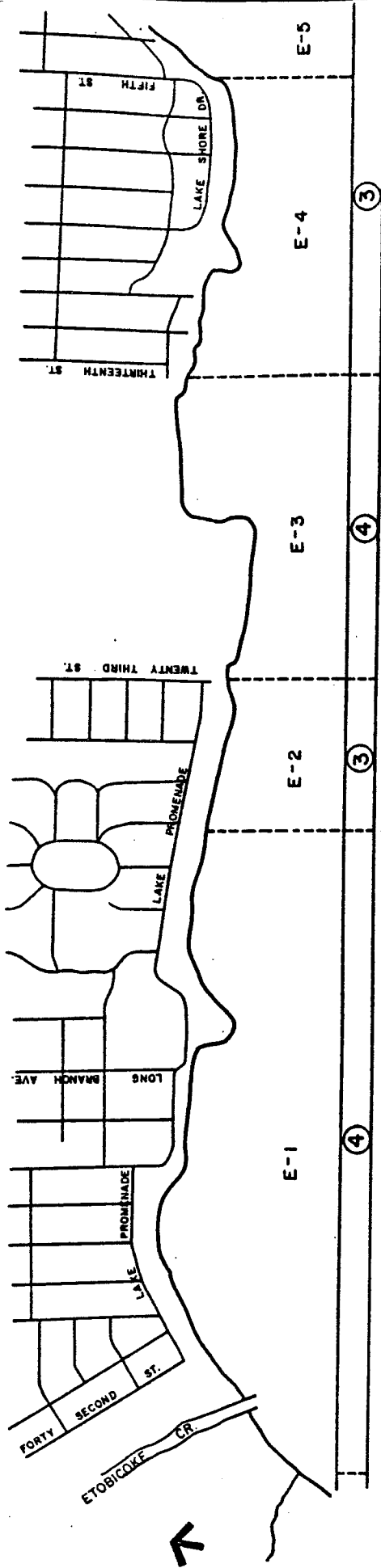
6. COSTS AND FINANCIAL IMPLICATIONS

In order to implement a comprehensive program of protective works along the shoreline, the Authority will require funding in the order of \$1,000,000 per year, at least for the early stages. This figure will decrease with time as more of the difficult, inaccessible areas have been corrected. This figure represents an increase of about 50% over current Authority expenditures on shoreline management. It is important to allocate this order of funding now. If delayed, the number of houses and the amount of property which can be saved will be dramatically reduced. The primary reason for this is that a great deal of the land which formed sizeable setbacks at the time of development has already been eroded, leaving whole streets of houses vulnerable within a ten to twenty year period if nothing is done now.

It is proposed that the funds required for this Program be raised on the basis of a 55% grant from the Province of Ontario, and that the Authority share, 45%, be raised on the basis of a levy assigned to the benefiting municipality where the works are located. The benefiting municipality would be either Metropolitan Toronto or the Region of Durham; however, most of the expenditures will be within Metropolitan Toronto.

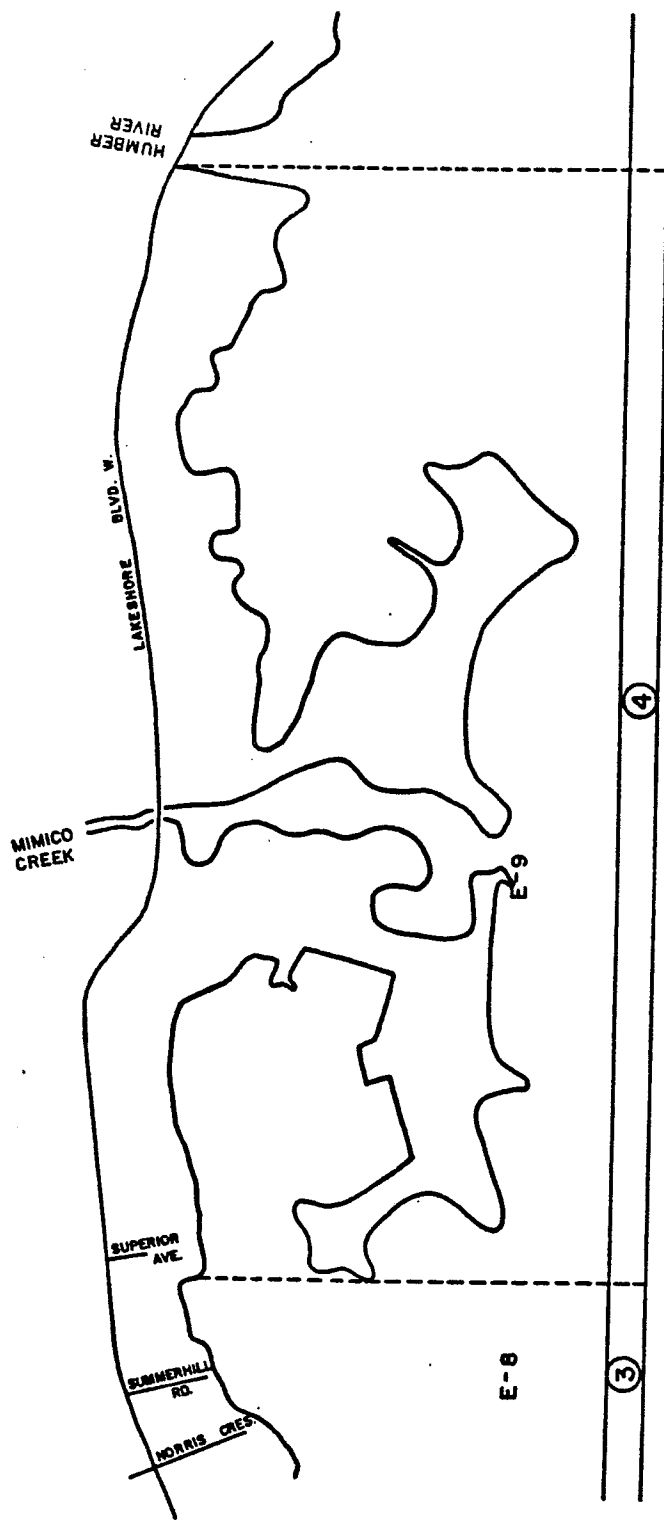
It is also important to recognize that shoreline management works will require maintenance in the future and the provision of funding for operations and maintenance. It is anticipated that the Authority's maintenance requirements, which by the end of 1981 will be at \$100,000 per year, will rise at the rate of 2% of the capital cost of the protective works installed: about \$20,000 per year in the short term. The works referred to include the shoreline protection of waterfront recreational areas for which the Authority retains maintenance responsibilities.

Details of the funding will be described in an implementation project which will be prepared after approval of this Program and the Watershed Plan.



LEGEND

- ★ MAJOR POTENTIAL ACCESS
- ② PRIORITY FOR PROTECTION



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★ MAJOR POTENTIAL ACCESS

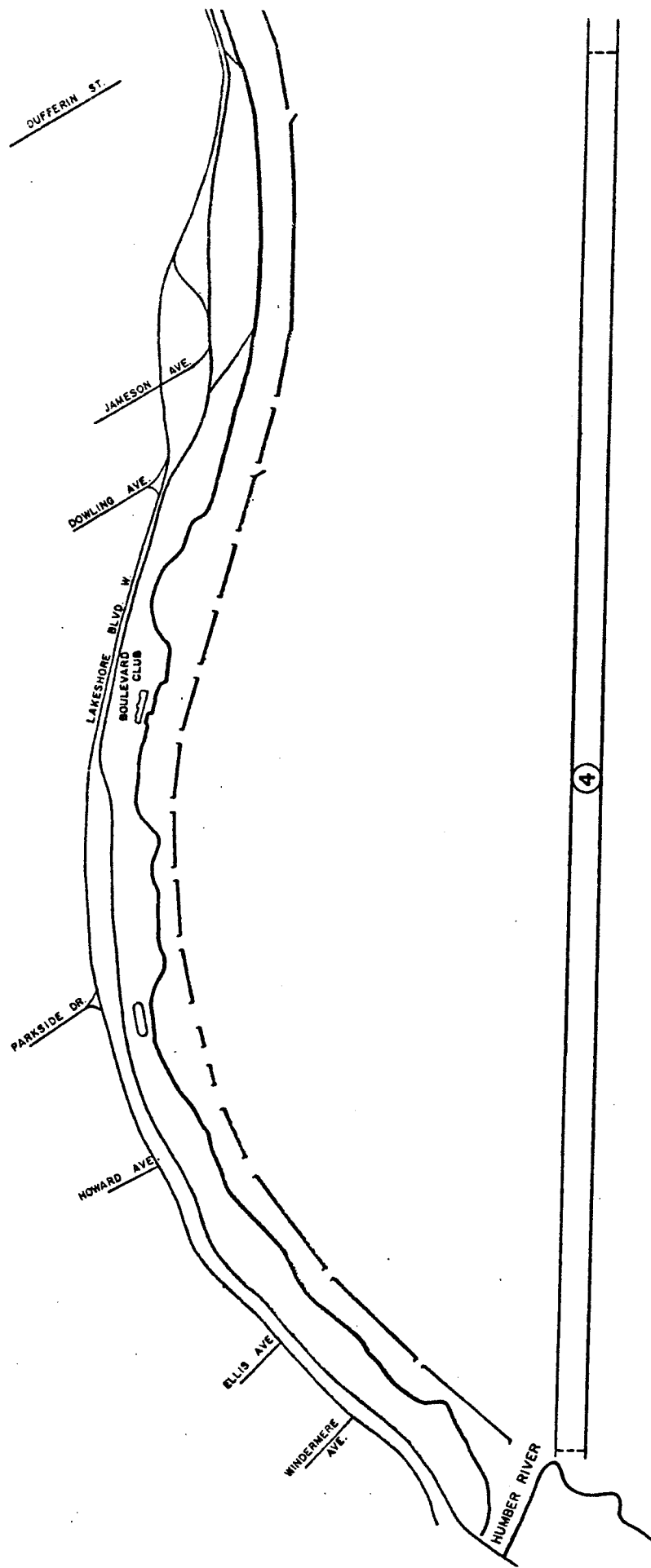
② PRIORITY FOR PROTECTION

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conservation authority

WATERSHED PLAN
SHORELINE MANAGEMENT PROGRAM

ACCESS AND PRIORITY
ETOBICOKE SECTOR

FIG. 8b



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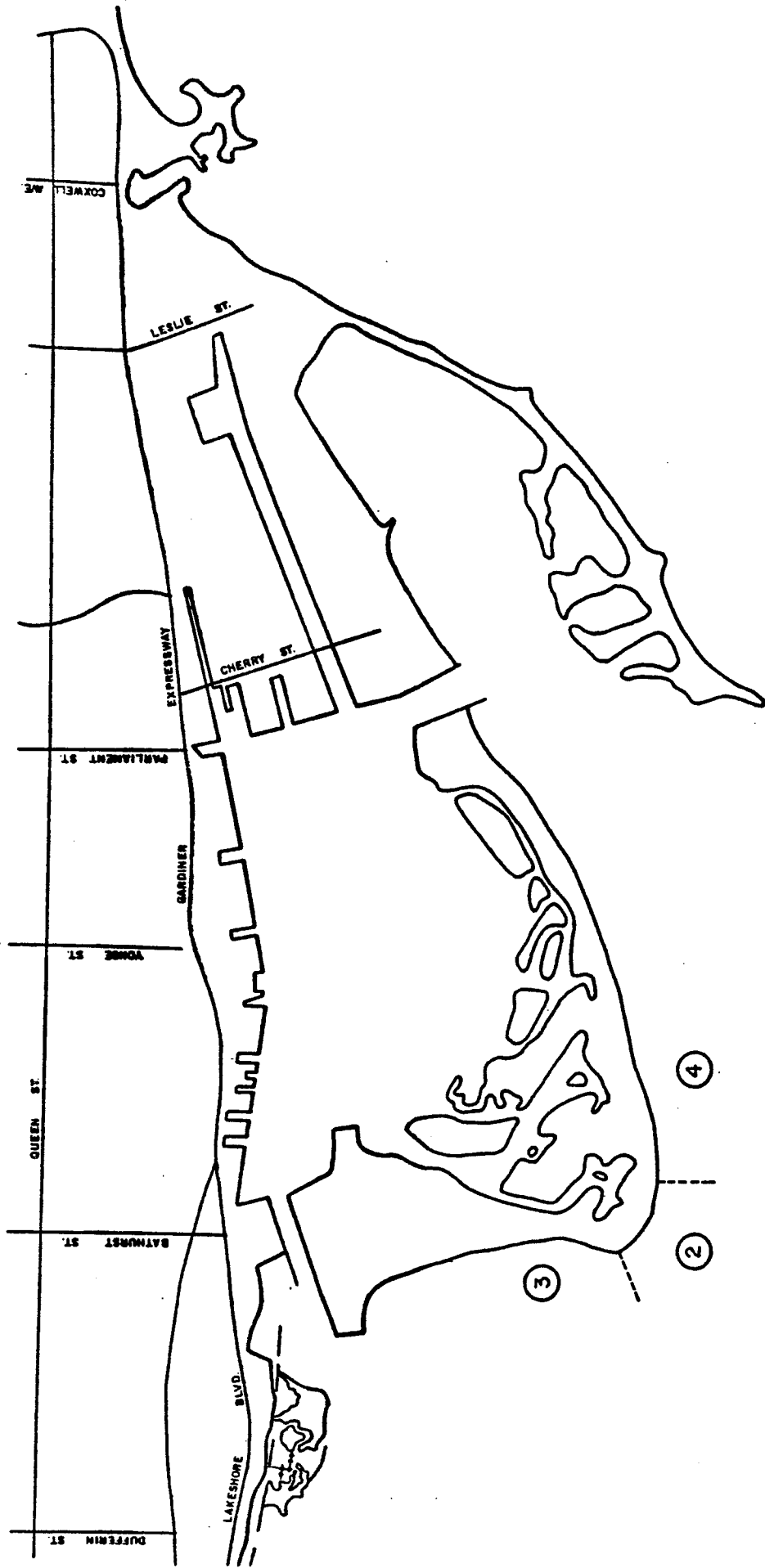
② PRIORITY FOR PROTECTION

WATERSHED PLAN
SHORELINE MANAGEMENT PROGRAM

ACCESS AND PRIORITY
CITY SECTOR

FIG. 8c

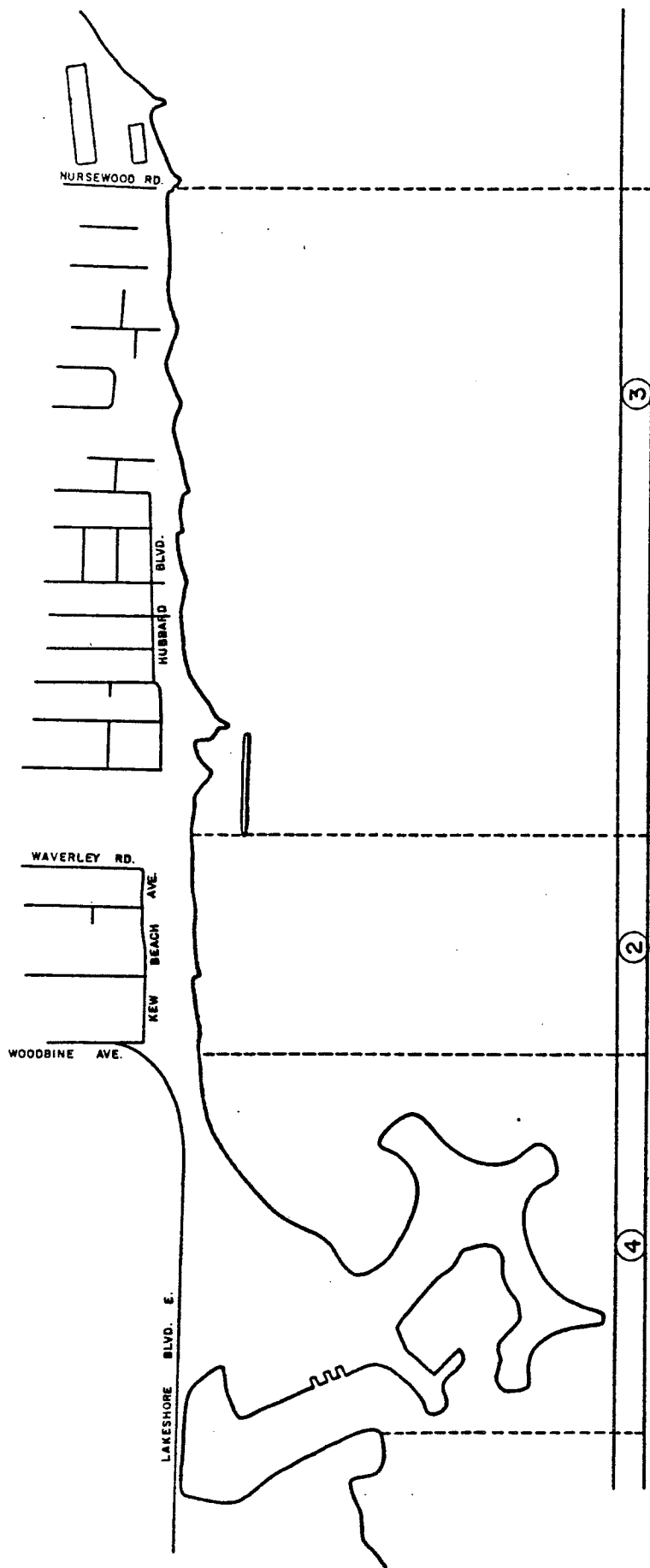
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- ★ MAJOR POTENTIAL ACCESS
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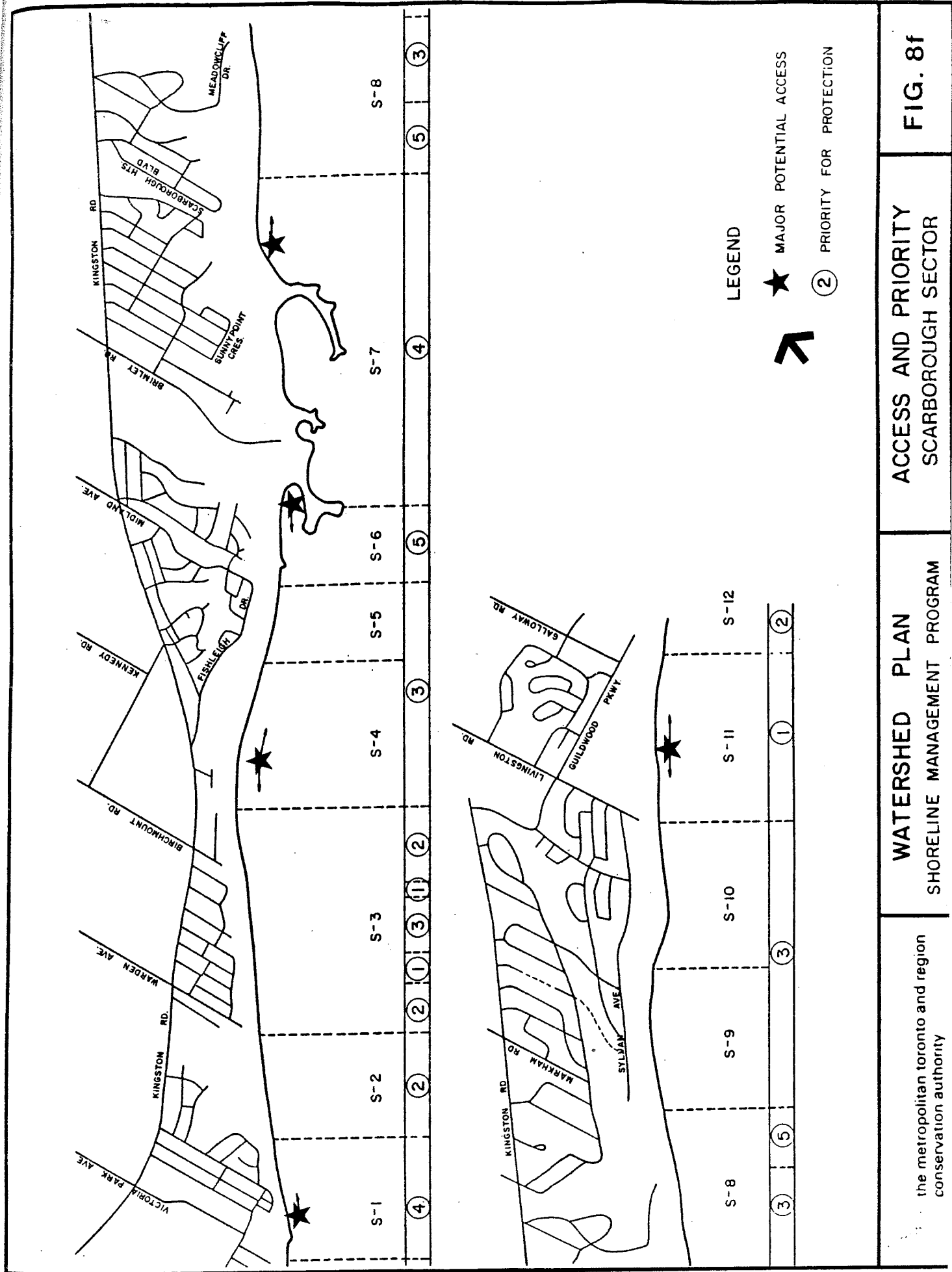


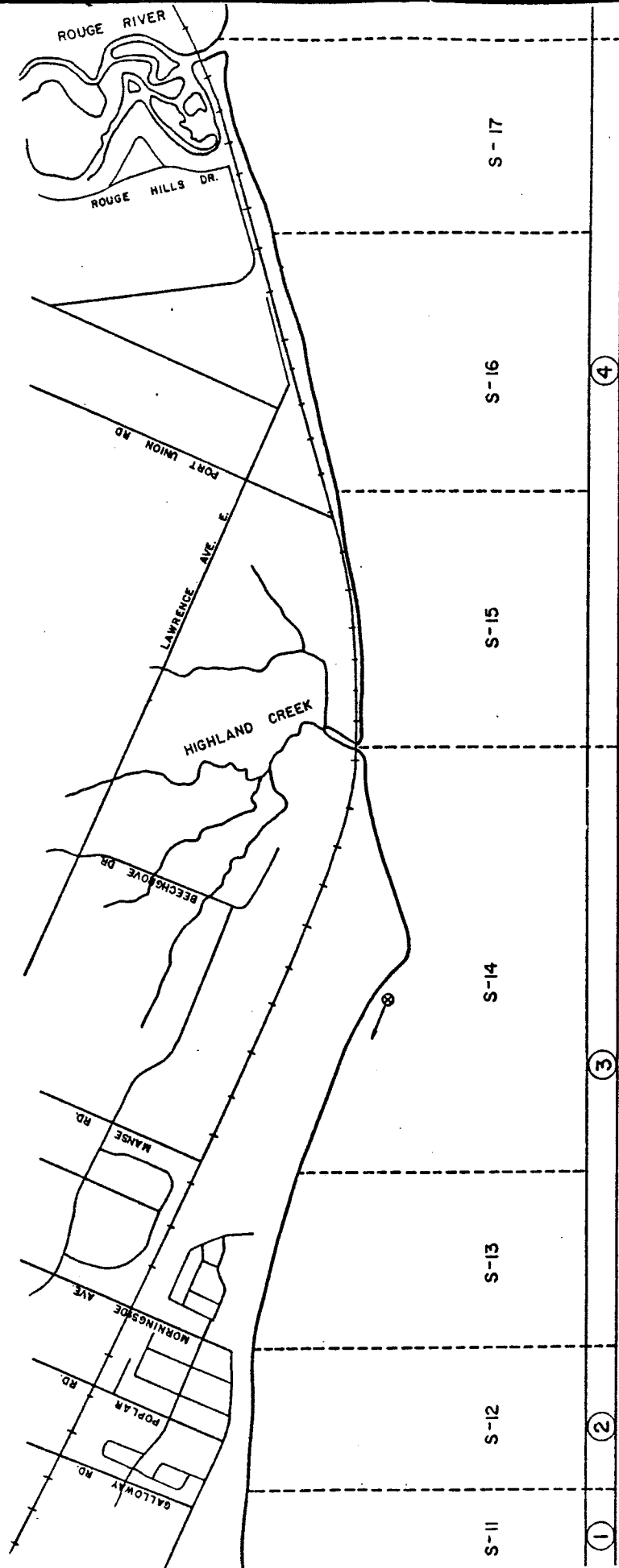
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★ MAJOR POTENTIAL ACCESS

② PRIORITY FOR PROTECTION





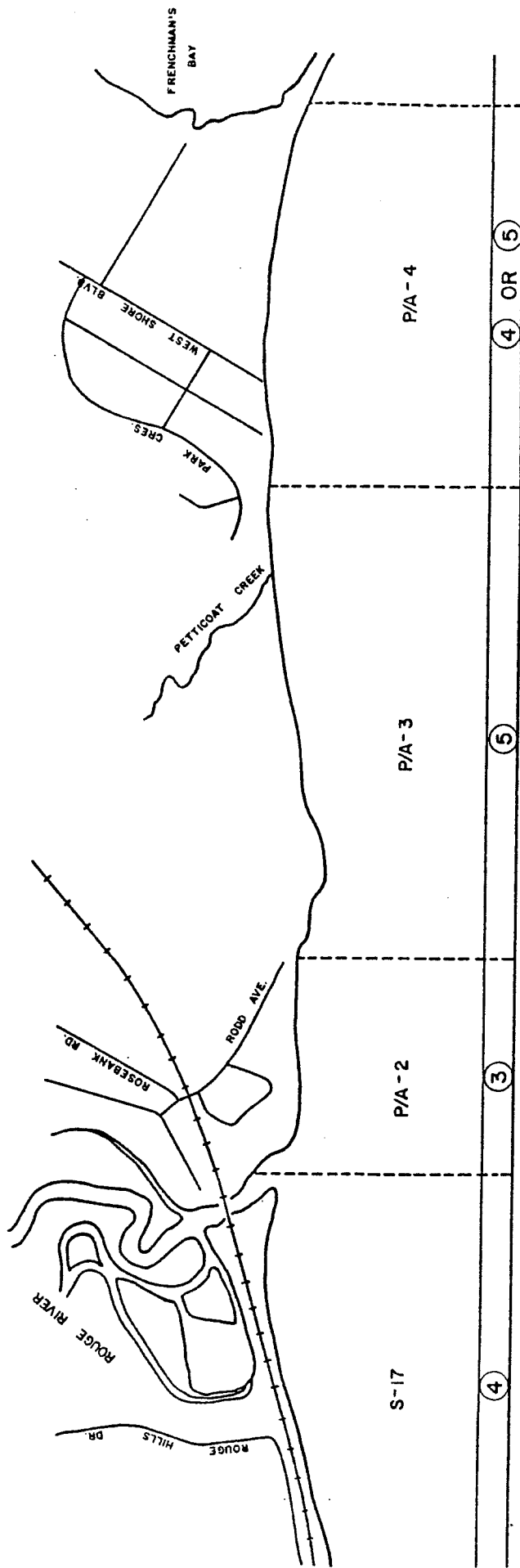


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- ★ MAJOR POTENTIAL ACCESS
- ② PRIORITY FOR PROTECTION

WATERSHED PLAN
SHORELINE MANAGEMENT PROGRAM

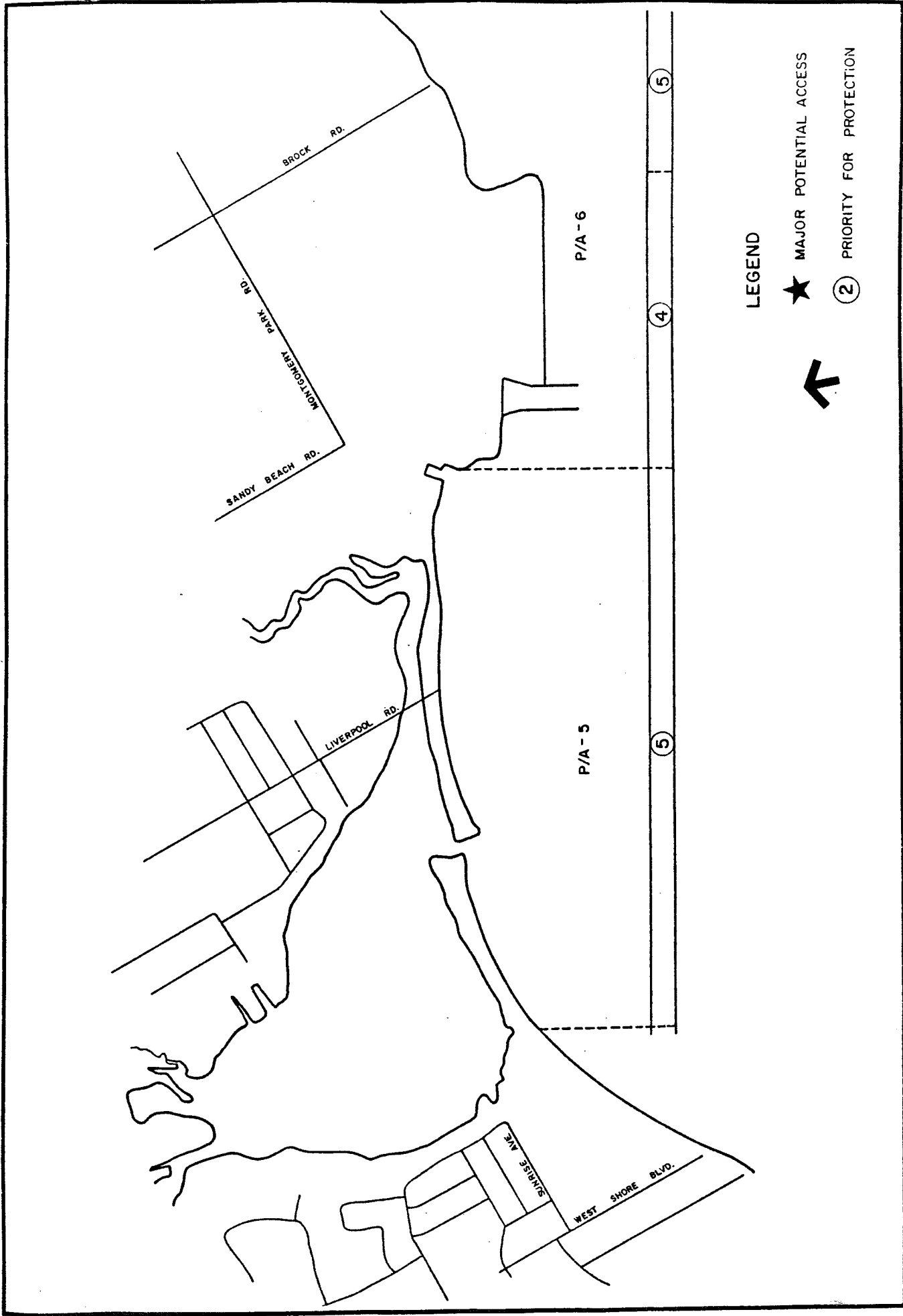
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LEGEND

- ★ MAJOR POTENTIAL ACCESS
- ② PRIORITY FOR PROTECTION

<p>the metropolitan toronto and region conservation authority</p>	<p>WATERSHED PLAN SHORELINE MANAGEMENT PROGRAM</p>	<p>ACCESS AND PRIORITY PICKERING/AJAX SECTOR</p>	<p>FIG. 8h</p>
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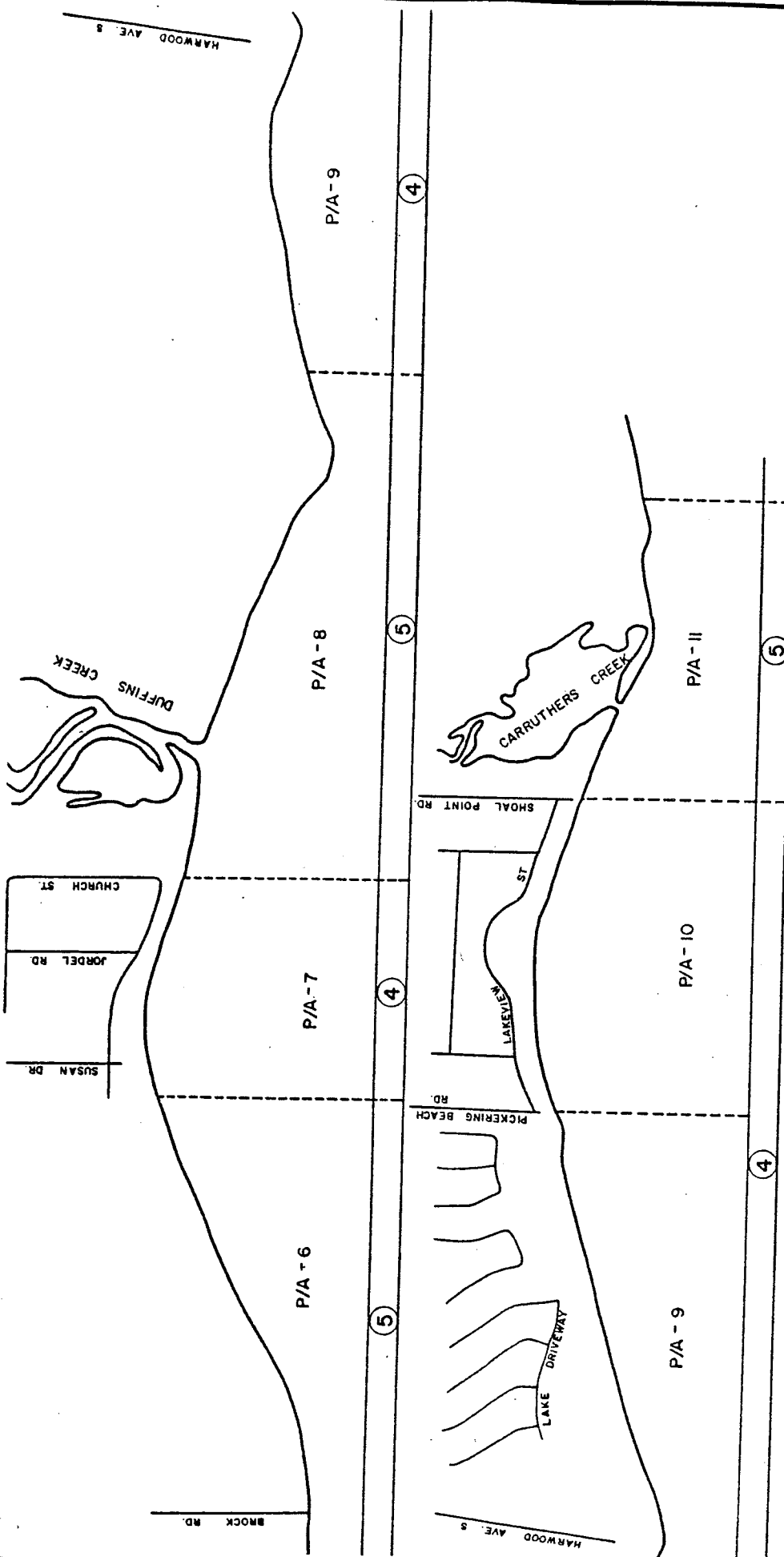


WATERSHED PLAN
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ACCESS AND PRIORITY
PICKERING/AJAX SECTOR

FIG. 8i

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PICKERING/AJAX SECTOR

FIG. 8j