APPENDIX E

Niagara-On-The-Lake
Dynamic Beach Evaluation and Regulatory Shoreline Hazard Update

Final Report
To : Aquafor Beech Ltd.

April 2006

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics

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1 Introduction

This report provides relevant discussion regarding the update of shoreline hazards, completed in conjunction with the Niagara-on-the-Lake Watershed Study. This update has focused on the evaluation of dynamic beach reaches along the Lake Ontario shoreline within the Niagara-on-the-Lake Watershed, but also includes a general update of the regulatory lines on the basis of updated topographic information. The update has been completed in accordance with the *Technical Guides for flooding, erosion, and dynamic beaches in support of natural hazards policies 3.1 of the provincial policy statement* (MNR, 2001).

The Lake Ontario Shoreline Management Plan (Dillon and Atria, 1994), prepared for the Niagara Peninsula Conservation Authority provides a general overview of the Study area from a coastal processes perspective, with general information regarding the shoreline geology and the environmental variables that affect the relevant coastal processes. Although the 1994 Shoreline Management Study included the entire Niagara Peninsula Conservation Authority's shoreline jurisdiction, and provides a relatively coarse definition of the local shoreline processes, the objective of this study is not to reassess the technical parameters that support the development of the 1994 hazard lands, but to review these parameters within the dynamic beach zones, adjusting as necessary. A number of technical parameters that were defined in the 1994 Shoreline Management Plan have been assumed to be valid for the shoreline areas that are not considered to be dynamic beach.

The NPCA has identified four reaches of shoreline as potential dynamic beach shoreline areas. These areas have been reviewed with regard to the most recent technical guidelines; the relevant descriptions of the areas and discussion of coastal processes and hazards are the primary focus of this report. The remaining shoreline reaches have been reviewed in a cursory manner, with adjustments to the hazard lines based on recent topographic information. Discussion is provided for areas where there are notable deviations from the existing shoreline hazard delineations.

2 Study Area

The Study area for this project includes the Lake Ontario shoreline extending from the Welland Canal, westerly to the Niagara River, as shown in **Figure 2.1**. The general shoreline includes a wide range of shoreline conditions, ranging from steep bluffs to low-lying sandy and marshy shoreline areas. The 1994 shoreline management plan suggests that the shoreline characteristics within the Study Area consist of a significant depth of sand till overlying the bedrock within the western portions of the area, which is overlain by a relatively thin veneer of silt till and silt. This veneer is substantially thicker in the vicinity of the Port Weller Jetties. To the east end of the Study Area, the bedrock is considerably higher, approaching low water datum. There is little sand till within the overburden in this area, but there are significant depths of silt till and silt within the overburden in this area.

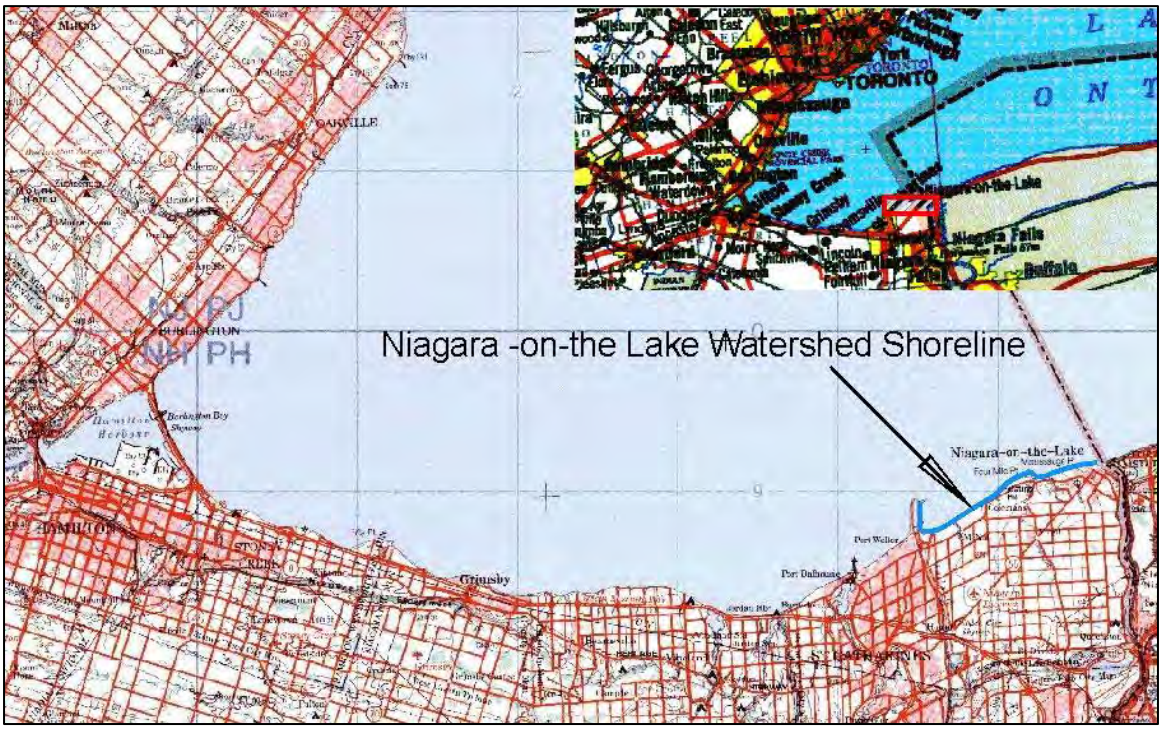

Figure 2.1 : Study Area

The 1994 shoreline management plan also identified 23 littoral zones along the shoreline between the Welland Canal and the Niagara River. These littoral zones were defined within three littoral sub cells on the basis of sediment transport and supply potentials. The three sub cells were generalized as follows:

- Port Weller (east of the Jetties), extending easterly for between 1 and 2 km, with net westerly sediment transport potential,
- A small sub cell centered at Stewart Rd. (approximately 1 km long) with negligible net sediment transport (a node), and
- From just east of Stewart Rd., easterly to the Niagara River, with net easterly sediment transport potential.

In accordance with the recommendations of the 1994 shoreline management plan, the current hazard lands policy of the Niagara Peninsula Conservation Authority has identified four (4) specific areas of "Dynamic Beach" shoreline within the Niagara-on-the-Lake subwatershed area. The location of these zones is depicted in **Figure 2.2**. The sites are identified according to their reach designations in the 1994 Shoreline Management Plan; reference is made to the littoral zone and associated description which was provided for each respective site in the 1994 shoreline management plan. Detailed discussion of the suggested dynamic beach reaches is provided in Section 5 of this report.

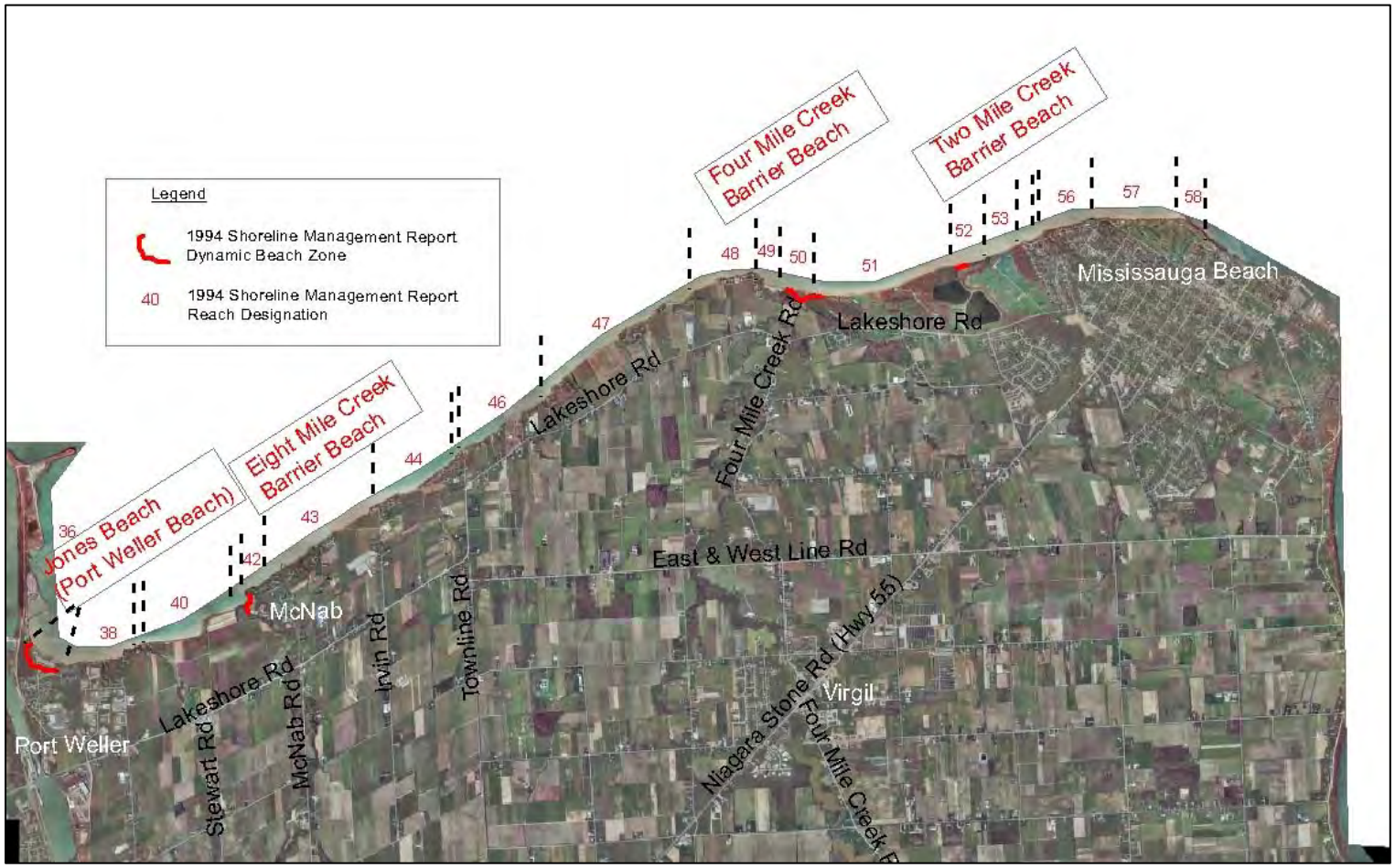

Figure 2.2 : Shoreline Delineation (As per 1994 Shoreline Management Report)

3 Overview of Hazards Lands Policies

Section 3.1 of the Provincial Policy Statement (regarding Natural Hazards Policies) provides guidance on the development of properties within defined hazards lands. The policy states:

3.1.1 Development will generally be directed to areas outside of:
a. hazardous lands adjacent to the shorelines of the Great Lakes - St. Lawrence River System and large inland lakes which are impacted by flooding, erosion, and/or dynamic beach hazards;
b. hazardous lands adjacent to river and stream systems which are impacted by flooding and/or erosion hazards; and
c. hazardous sites.

3.1.2 Development and site alteration will not be permitted within:
a. defined portions of the dynamic beach;
b. defined portions of the one hundred year flood level along connecting channels (the St. Mary's, St. Clair, Detroit, Niagara and St. Lawrence Rivers); and
c. a floodway (except in those exceptional situations where a Special Policy Area has been approved).

3.1.3 Except as provided in policy 3.1.2, development and site alteration may be permitted in hazardous lands and hazardous sites, provided that all of the following can be achieved:
a. the hazards can be safely addressed, and the development and site alteration is carried out in accordance with established standards and procedures;
b. new hazards are not created and existing hazards are not aggravated;
c. no adverse environmental impacts will result;
d. vehicles and people have a way of safely entering and exiting the area during times of flooding, erosion and other emergencies; and
e. the development does not include institutional uses or essential emergency services or the disposal, manufacture, treatment or storage of hazardous substances.

3.1 General Hazard Land Limits

The definition of hazard lands along the shorelines of the Great Lakes (and connecting channels) requires the determination of the expected hazards associated with:

- flooding processes
- erosion processes, and
- dynamic beach processes

The governing hazard limit is the greatest of the three possible hazard delineations noted above. The hazard land limits are typically defined within the scope of a relatively broad study, and rely on general characterization of the shoreline (into similar reach sections), and determination of the respective hazards associated with each reach. The hazard lines are then mapped in accordance with these generally defined hazards.

Due to the relatively broad scope of the regulatory mapping process, site specific processes and shoreline features which may result in local phenomena which influence the respective hazards cannot be considered in detail. The topographic information used in the overall hazard land mapping process may also not account for local irregularities in topographic and shoreline features. Therefore the hazard lines mapped on the basis of this level of study may not reflect small scale sensitivities that may be identified through detailed analysis. The Provincial Policy respects this fact, allowing for the consideration of detailed engineering investigations at various levels of development planning.

3.2 Flood Hazard Limits

The Regulatory Flood Hazard Limit considers the combined effect of the 100 water level (including static level + wind setup) and a flood allowance for wave uprush and other water related hazards (e.g. ponding).

The 100 year flood level is represented by a contour line, by rounding the defined water level up to the first even (1m interval) contour elevation. The allowance for wave uprush and other water-related hazards is represented by horizontal offset from the representative contour for the 100 year flood line. In the absence of studies to determine site specific uprush and other water related hazards, the allowance for Great Lakes shorelines is 15 m.

Where flooding and/or wave action overtops a natural bank or protection works causing ponding landward of the 100 year flood level, the allowance for water related hazards is to be determined by a study using accepted engineering principles.

3.3 Erosion Hazard Limits

Shoreline erosion is a function of numerous physical and environmental factors, including:

- Shoreline geology and orientation
- Wave action
- Water levels
- Nearshore currents
- Groundwater
- Ice
- Wind

The Provincial Policy defining the Erosion Hazard Limit accounts for the establishment of a stable slope, a shoreline recession based on the average annual recession rate and an erosion allowance. The determination of the Erosion Hazard depends on the availability of historic shoreline information (typically aerial photographs) and involves a two step process.

Step one requires the determination of an erosion allowance from the toe of the shoreline bluff and assumes either:

- the sum of a stable slope allowance plus 100 times the average annual recession rate measured landward from the toe the shoreline cliff, bluff or bank (for shorelines where a minimum of 35 years of recession information is available)

OR

- The sum of the stable slope allowance plus a minimum 30 m erosion allowance measured landward from the toe the shoreline cliff, bluff or bank (for shorelines where insufficient recession rate information is available).

Step two requires the comparison of the limit defined in step one with:

- A minimum 30 m erosion allowance measured landward from the top of the shoreline cliff, bluff, bank, or first lakeward break in slope.

The greater of the limits defined in Step 1 and Step 2 are used to define the Regulatory Erosion Hazard Limit.

It is important to note that the Erosion Hazard is applied to all shorelines of the Great Lakes except where dynamic beach shorelines exist.

3.4 Dynamic Beach Limits

Because the Dynamic Beach hazard limits are the focus of this review, they are discussed in more detail here than the other hazard definitions.

The Province of Ontario has defined Dynamic Beach Hazards to exist where:

- beach or dune deposits exist landward of the water line; AND
- beach or dune deposits overlying bedrock or cohesive materials are equal to or greater than 0.3 m in thickness, 10 m in width and 100 m in length along the shoreline; AND
- where the maximum fetch distance measured over an arc extending 60 degrees on either side of a line perpendicular to the shoreline is greater than 5 km. (This usually does not occur where beach or dune deposits are located in embayments, along connecting channels and in other areas of restricted wave action where wave related processes are too slight to alter the beach profile landward of the water line.)

The dynamic beach definition is recognized due to the fact that it is not possible to define the landward extent of a dynamic beach on the basis of any one elevation, and that the hazard associated with a dynamic beach must be evaluated on the basis of the possible profile changes along that beach in response to the environmental variables that may exist over a broad range of time scales.

The delineation of the dynamic beach hazard includes:

Landward limit of the flooding hazard (100 year flood level plus an allowance for wave uprush and other water related hazards)
+
dynamic beach allowance of 30 m (on Great Lakes)

Where the dynamic beach has been found to be erosional or receding, the landward limit of the dynamic beach would also include a horizontal distance representing 100 times the average annual recession rate.

There are also several circumstances which may require that the landward limit of the dynamic beach would be relocated lakeward of that defined by the standard dynamic beach hazard. Such circumstances include:

- Locations where a cliff or bluff consisting of cohesive sediments or bedrock exists landward of the beach (and the toe of the bluff served to limit the landward extent of the beach profile developments) the dynamic beach hazard limit should be defined at the toe of the bluff, with the stable slope allowance and erosion allowance applied to the bluff to determine the overall hazard land definition;
- In locations where the dynamic beach exists on a narrow barrier beach system and the standard definition of the dynamic beach hazard would situate the limit within the waterbody that is protected by the barrier, the dynamic hazard limit should be defined at the toe of the barrier slope on the landward side of the beach (intersection of unconsolidated beach material and natural bed of the waterbody);
- In locations where the beach (and associated dune deposits) are low-lying and the flooding hazard inundates the beach area, or extends landward of the beach deposits, the dynamic beach hazard limit should be defined as the lesser of:
    - the landward limit of the beach and associated dune deposits (i.e. the boundary of the beach (and associated dune deposits) and the material forming the leeward low-lying plain), or
    - 30 meters landward of the first break in slope on the lee side of the first dune.

Shoreline classification within the context of the Dynamic Beach definition is based on three primary classifications, with various possible sub-classifications, permitting the possibility of 18 different classifications. The classification scheme includes:

- Beach Profile Type
    - Cliff/bluff
    - Low plain
    - Barrier
- Beach Planform and Exposure
    - Headland-bay
    - Partial headland
    - Exposed

- Beach Materials
  - Gravel, cobble or boulder
  - Sand

The dynamic nature of the beach may also depend on:

- Whether the beach profile is fully developed in sediment, or instead is underlain by bedrock or cohesive materials which act to limit the dynamic range of the beach profile; and
- Whether the beach is the product of natural processes or has been artificially created in part, or as a whole by structures and/or beach nourishment.

Typical definitions of the Dynamic Beach hazards are shown graphically in **Figures 3.1 to 3.5**.

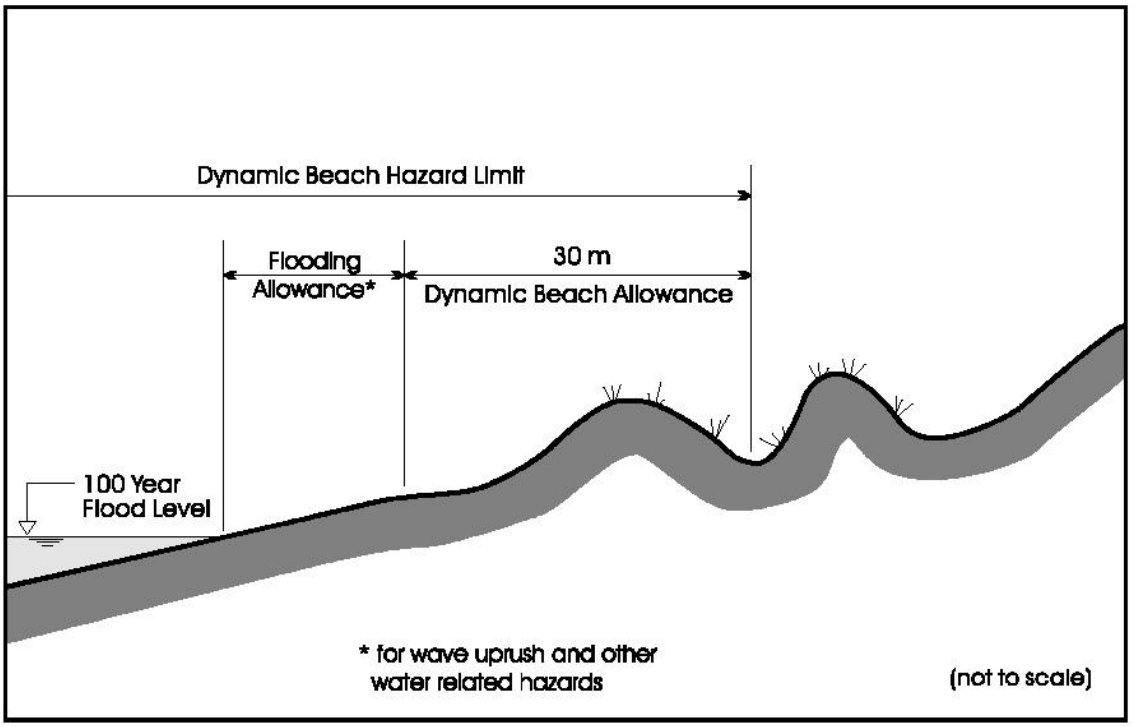

Figure 3.1 : General Definition of Dynamic Beach Hazard Limit
Source: MNR, 2001

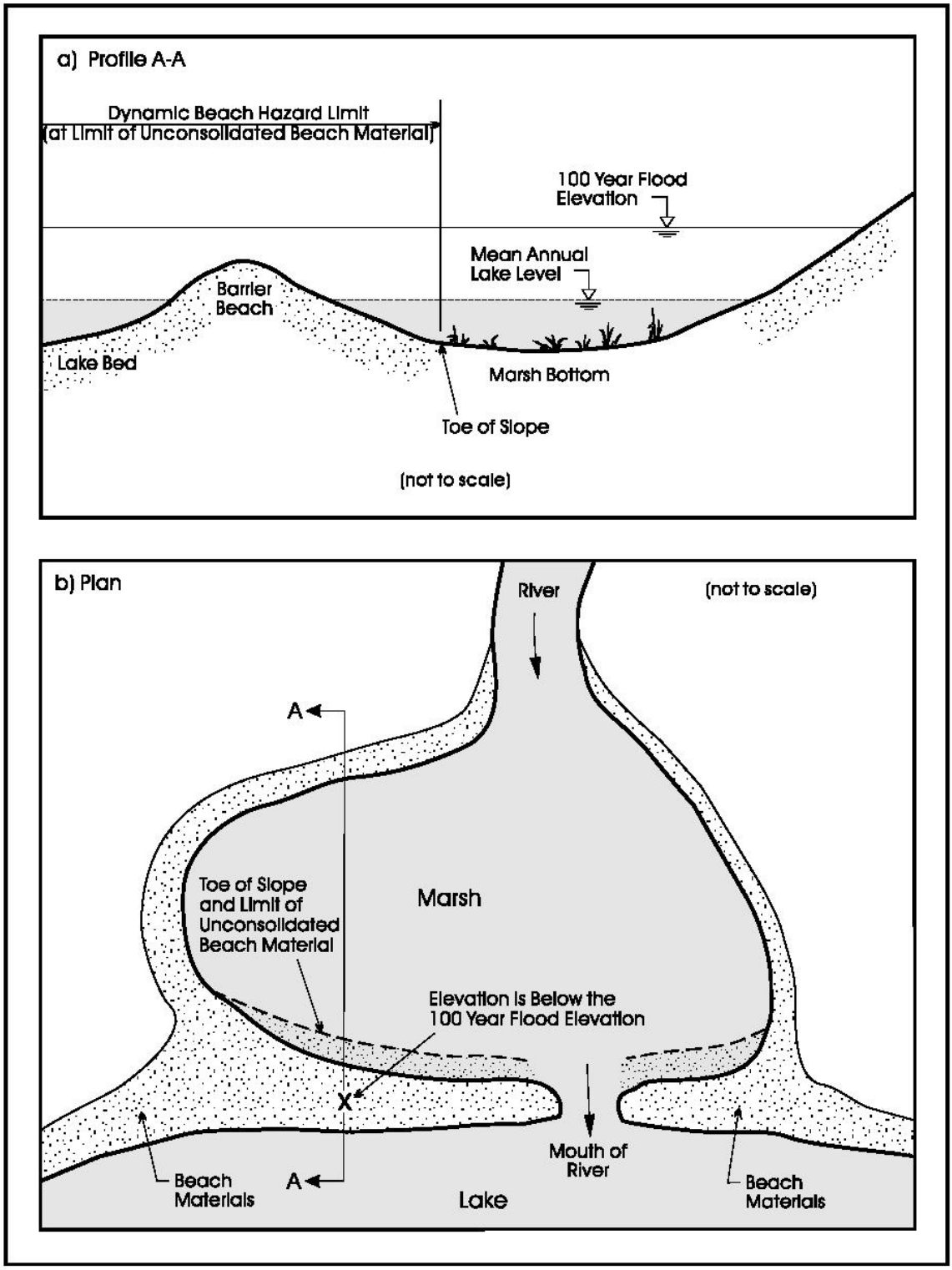

Figure 3.2 : Dynamic Beach Hazard Limit on Barrier Beach

Source: MNR, 2001

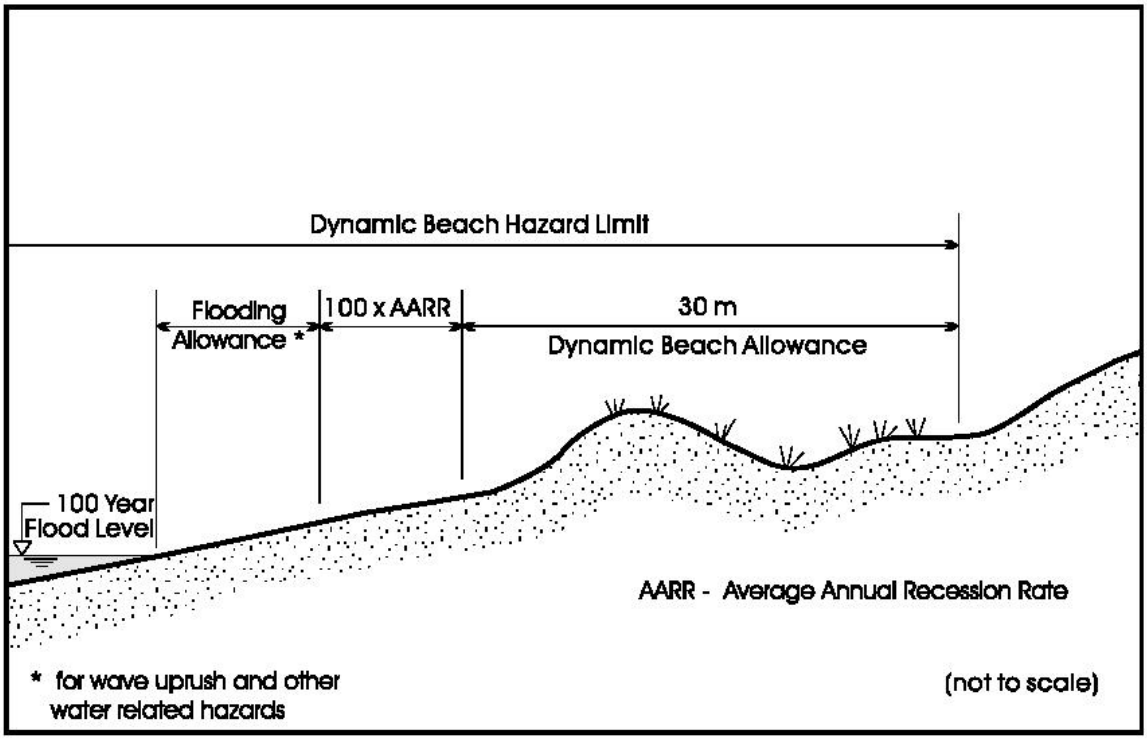

Figure 3.3 : Dynamic Beach Hazard Limit on Receding Shoreline

Source: MNR, 2001

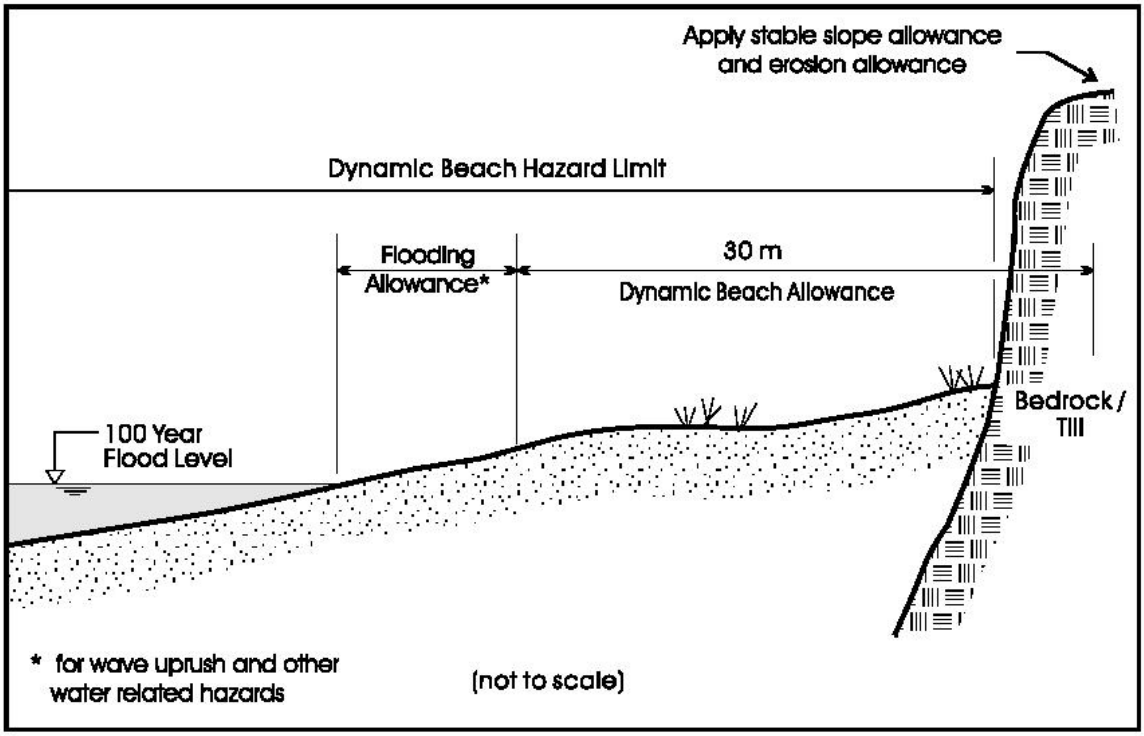

Figure 3.4 : Dynamic Beach Hazard Limit on Beach Backed by Bluff

Source: MNR, 2001

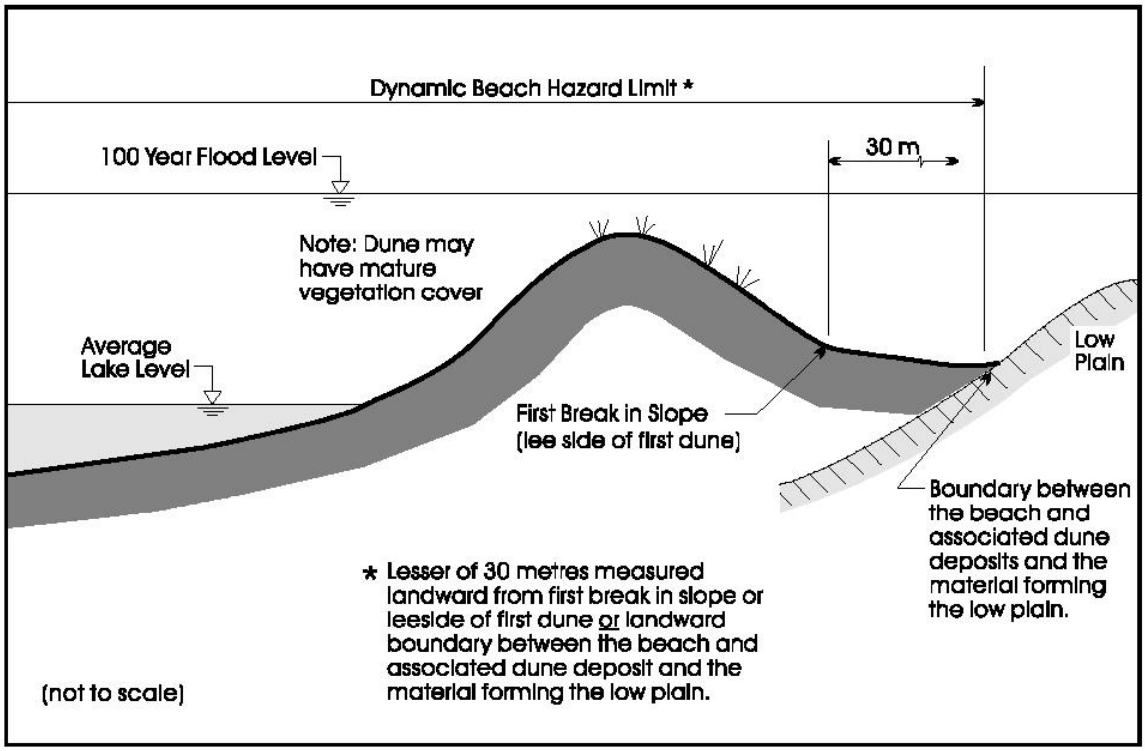

Figure 3.5 : Dynamic Beach Hazard Limit on Beach Backed by Low Plain
Source: MNR, 2001

4 Review of 1994 Shoreline Management Report

As previously noted, the 1994 Shoreline Management Report provided a relatively thorough assessment of the shoreline hazard limits. The technical information provided in that report has for the most part been accepted for the update of the Regulatory Shoreline Hazard Line mapping. The reach definitions employed in the 1994 report have been maintained as well for sake of consistency.

Characteristic reach parameters defined in support of the 1994 hazard delineation are presented in Table 4.1. Table 4.1 reflects one adjustment to the 1994 table, swapping the nearshore definitions for Reach 41 and 42 on the basis of field investigation. It is also important to note those (shaded) cells of the table that relate to reaches which are discussed specifically in this report in Sections 5 and 6.

The 1994 report also provides a technical discussion of the various physical and environmental variables that define the hazards limits. The probabilistic nature of water levels, wave conditions and direction are discussed in that report with regard to water related hazards; stable slope allowance considerations are also discussed. In summary, the 1994 Shoreline Management Report determined that the standard 15 m setback from the 100 year flood level was consistent with the technical analyses with respect to providing for wave uprush and associated water related hazards. The standard 3:1 stable slope allowance was also found to be appropriate for determination of the erosion hazard limit.

Table 4.1 : Summary of Shoreline Characteristics (Dillon and Atria, 1994)

Reach No.	Description	Length (m)	Shoreline Type			Representative Recession Rate (Annual) (m)	Wave Climate
			Onshore	Water's Edge	Nearshore		
35	Welland Canal west	300	fill with protection	canal entrance structures	glacial material/ silt-sand	n/a	n/a
36	Welland Canal east	300	fill with protection	canal entrance structures	glacial material/ silt-clay/silt-sand	n/a	n/a
37	Jones Beach	330	low plain (O-1-50)	sandy beach	glacial material/silt-clay	0.00	n/a
38	West of Newport St. to Butkin Drain	830	med. Glacial bluff	structures	glacial material/silt-clay	0.70	n/a
39	Butkin Drain	160	med. Glacial bluff	creek mouth narrow beach	glacial material	1.8	n/a
40	Butkin Drain to Eight Mile Creek	860	med. Glacial drift bluff (O-1-40)	creek mouth minimal beach	glacial material	2.5	n/a
41	Eight Mile Creek	250	Barrier beach	creek mouth sandy beach	glacial material	2.0	Point 7
42	Eight Mile Creek to east of Firelane 14	400	med. Glacial drift bluff	structures	glacial materials with boulders	1.5	Point 7
43	Eight of Firelane 14 to west of Firelane 12	1050	med. Glacial drift bluff	structures/ narrow beach	glacial material	2.0	Point 7
44	West of Firelane 12 to Six mile Creek	1030	low/med. Glacial drift bluff (O-1-30)	structures	glacial material	1.2	Point 8
45	Six mile creek	70	creek mouth/low glacial drift bluff	banks lined	glacial material	1.1	Point 8
46	Six mile creek to east of Firelane 6	1120	low glacial drift bluff	structure minimal to no beach	glacial material	1	Point 8

Table 4.1 (Cont) : Summary of Shoreline Characteristics (Dillon and Atria, 1994)

Reach No.	Description	Length (m)	Shoreline Type			Representative Recession Rate (Annual) (m)	Wave Climate
			Onshore	Water's Edge	Nearshore		
47	West of fire lane 6 to Firelane 4	1550	low plain/low glacial bluff (O-1-20)	structure minimal to no beach	glacial material to the west and glacial material with boulders to the east	0.6	Point 8
48	Firelane 4 to Four mile point	800	low glacial drift bluff	structures	glacial material with boulders	0.6	Point 8
49	Firelane 2A	190	low plain	sandy beach	glacial material with boulders	0.8	n/a
50	Four Mile Creek	440	barrier beach/low glacial drift bluff	narrow sandy beach /creek mouth	glacial material with boulders	1.2	Point 9
51	Four Mile Creek to Two Mile Creek	1200	med. glacial drift bluff	narrow sandy beach	glacial material with boulders	1.5	Point 9
52	Two Mile Creek	440	barrier beach/med glacial drift bluff	narrow sandy beach /creek mouth	glacial material	0.8	Point 9
53	Rifle Range	250	low/med glacial drift bluff	narrow sandy beach	glacial material	0.8	Point 9
54	Shakespeare Ave. to One Mile Creek	220	low glacial drift bluff (O-1-9)	sandy beach/structures	glacial material	0.8	Point 9
55	One Mile Creek	75	creek mouth	structures	bedrock	0.3	Point 9
56	Niagara Blvd.	530	low/med glacial drift bluff	structures	bedrock	0.3	Point 9
57	Niagara Blvd. to Mississauga Point	800	med. glacial drift bluff	narrow cobble beach	bedrock	0.3	Point 9
58	Mississauga Point to NOTL marina (beyond study limit)	1500	med. glacial drift bluff	narrow cobble beach	bedrock	0.3	n/a

5 Evaluation of Dynamic Beach Sites

The dynamic beach sites defined in the 1994 Study were visited in the fall of 2005 (August 30). The physical characteristics of the beach were considered with regard to the Provincial Policy definitions of a dynamic beach. Historic aerial photos were obtained (from the Canadian National Air Photo Library) for these areas and historic shoreline progression was considered. Shoreline locations were estimated with due consideration of the mean monthly water level when the photo was taken, and the typical nearshore slope as defined by available bathymetric mapping. It is noted that there are limited images for this area that are of suitable resolution for shoreline definition. Therefore, adequate assessment of shoreline progression rates was not possible in some cases.

The dynamic beach reaches are discussed individually in the following sections.

5.1 Reach 37: Jones Beach (Port Weller East)

The beach situated immediately east of the Port Weller jetties is sheltered to a large degree from the westerly waves by the Port Weller jetties, and is stabilized at the eastern end by a gabion shorewall.

The 1994 shoreline management plan describes the 330 m long beach as a low plain shoreline structure with sandy beach at the waterline, and glacial silt/clay materials in the nearshore area. The status of the beach was considered to be unaltered at that time, without any recessional tendencies; at present, there is a condominium development along the back of the beach area, situated well within the defined 1994 Dynamic Beach Hazard Limit. It is also evident that beach maintenance is ongoing in this area, as seen in **Figure 5.1**, which depicts the present beach conditions. Technical documentation supporting the condominium development proposed some minor shore protection works along the eastern portion of the beach, and cites accretion rates of approximately 3 m/yr (Proctor and Redfern, 1988)

A review of historic aerial photographs does suggest that the beach in the area is not erosional, probably due to the protection afforded by the Port Weller jetties. Classification of this beach within the Dynamic Beach Sub-Classification system would suggest a "Low Plain Headland-Bay Sand Beach" system (Sub-Class # 2-1-3), although the headland structures are not natural. Given this sub-class, and the inundation of the entire beach profile by the Regulatory Flood, the Dynamic Beach Extents have been defined at the transition from the unconsolidated beach materials to the low plain (typically the landscaped edge of the condominium development).

The Provincial Policy indicates that the Erosion Hazard Limit is not defined for areas of Dynamic Beach, and therefore only the Dynamic Beach and Regulatory Flood Hazard Limits are defined for this area (See Appendix A). It is noted that the Regulatory Flood Hazard Limit is the most landward hazard defined for this reach.

Figure 5.1: Jones Beach (Port Weller East)

5.2 Reach 41: Eight Mile Creek Barrier Beach

This beach is situated at the mouth of Eight Mile Creek (Airport Drain). The 1994 Shoreline Management Report (Table 2) has indicated that Reach 42 is a dynamic beach section, while reach 41 is a glacial drift bluff. Consideration of other characteristics described in that report and visual inspection of the site suggests that the report has confused the designation of the two reaches, and in fact Reach 41 is the Dynamic beach reach. The 1994 report describes this 250 m long beach as a natural silt mud beach with sand material at the water's edge and glacial material offshore. A representative recession rate of 2.0 m per year is suggested for this unaltered stretch of shoreline.

Visual inspection of this area in late August of 2004 indicated that the beach width is virtually zero over the entire length of this reach, with shoreline erosion having claimed a number of trees at the back of the beach. A relatively narrow band of silt/sand material is evident in the nearshore zone, with the creek outlet cutting through this material. The section of beach immediately west of the creek mouth is shown in **Figure 5.2**.

Figure 5.2: Eight Mile Creek (Airport Drain) Barrier Beach

The beach was not readily accessible by land. The shoreline to the immediate west consists of a relatively high glacial drift bluff with an estimated erosion rate of 2.5 m/yr. The shoreline to the east is defined with an annual recession rate of 1.5 m /yr (Dillon and Atria, 1994) but is also noted to be protected by structures. This protection maintains at headland feature immediately east of the creek outfall.

A review of historic aerial photographs does confirm a significant recession rate for the shoreline in this reach. An estimated recession rate of 1.7 m per year is consistent with the 1994 estimated recession rate of 2.0 m/yr. The barrier beach is inundated by regulatory flood levels, and classification of this beach within the Dynamic Beach Sub-Classification system would suggest a "Barrier Partial Headland Sand Beach" system (Sub-Class # 3-2-3). Given this sub-class, and the inundation of the barrier beach profile by the Regulatory Flood, the Dynamic Beach Extents have been defined at the toe of the barrier slope on the landward side of the barrier.

The Provincial Policy indicates that the Erosion Hazard Limit is not defined for areas of Dynamic Beach; however, given the recessional nature of the this reach (and the reach to the west) and the riverine setting landward of the barrier beach, the Erosion Hazard Limit has been shown (in Appendix A) for reference purposes and for integration with river reach hazard lines.

5.3 Reaches 49 and 50: Four Mile Creek Beach

The beach at the outlet of Four Mile Creek is part of the largest natural sand beach along the Niagara-on-the-Lake Watershed shoreline. Although the barrier beach identified by the 1994 shoreline management plan is only identified as 440 m in length, adjacent shorelines exhibit natural sandy beach sections as well. Immediately west of the Four Mile Creek outlet, a 200 m± length of sand beach exists along the frontage of the residences on Firelane 2A. To the east, a narrow sand beach fronts relatively high glacial drift bluffs over a length of approximately 1200 m; this section of shoreline then transitions to the barrier beach at Two Mile Creek (discussed in Section 5.4).

5.3.1 Reach 49 : Low Plain Beach

Visual inspection of the site in August, 2004, indicate that the beach to the west of the creek mouth (Reach 49) should be classified as dynamic beach as well. The beach to the west of Four Mile Creek is reported by local residents to be aggrading. This beach is anchored at the west end by a protected headland under residential development. Typical conditions within Reach 49 are depicted in **Figure 5.3**.

Figure 5.3: Looking West from Just West of Four Mile Creek

A review of historic aerial photographs shows that this reach is a historic river mouth / barrier beach site, where Four Mile Creek cut west from its current outlet behind a barrier beach outletting near the western end of Reach 50 in 1934. At this time, the beach was located offshore of its present location. The next available aerial photo (1960) shows the outlet in its current location with a recessed beach line, and subsequent aerial photos indicate a stable (slowly accreting) beach face. As indicated in the 1994 Shoreline Management Report (description of Reach 50), there is rubble at the west side of the creek, and the site inspection indicates that the present creek mouth is maintained to some degree, probably by the local residents.

This is a low plain beach, inundated by regulatory flood levels, and classification of this beach within the Dynamic Beach Sub-Classification system would suggest a "Low Plain Partial Headland Sand Beach" system (Sub-Class # 2-2-3). Given this sub-class, and the inundation of the beach profile by the Regulatory Flood, the Dynamic Beach Extents have been defined at expected transition between the unconsolidated beach material and the low plain. This line has been established on the basis of the location of the historic river mouth, and established mature trees.

As previously noted, the Provincial Policy indicates that the Erosion Hazard Limit is not defined for areas of Dynamic Beach, and given the stable/accretional nature of this reach, only the Dynamic Beach and Regulatory Flood Hazard Limits are defined for this area (See Appendix A). It is noted that the Regulatory Flood Hazard Limit is the most landward hazard defined for this reach.

5.3.2 Reach 50 : Barrier Beach

The 1994 shoreline management plan indicates that the barrier beach (Reach 50) at Four Mile Creek is 95% natural (with limited rubble protection on west side of creek) and it exhibits a representative recession rate of 1.2 m/yr. The water's edge is described as a narrow sandy beach with glacial material and boulders in the nearshore zone. There are no obvious signs of active erosion or recession of the beach immediately east of the creek mouth, although a little further to the east, it is obvious that the bluffs that back the narrowing beach in this area are in an active state of erosion. Typical conditions along the beach sections immediately east of the creek mouth and further to the east fronting the bluffs are depicted in **Figures 5.4** and **5.5** respectively.

A review of historic aerial photographs is inconclusive with respect to recession of this shoreline. The trends suggest that the beach is relatively stable in the immediate vicinity of the creek mouth, with recessional tendencies increasing towards the east. This is consistent with a net westerly littoral drift in this region (Shoreline Management Plan) and the probably sediment delivery function of Four Mile Creek. Given the inability to define a typical recession rate for this reach, the estimated 1.2 m annual rate presented in the 1994 was maintained.

Figure 5.4: Looking East from Just East of Four Mile Creek

Figure 5.5: Looking East Along Bluffs East of Four Mile Creek

Classification of this beach within the Dynamic Beach Sub-Classification system would suggest a "Barrier Exposed Sand Beach" system (Sub-Class # 3-3-3) be used. The minor rubble works at the western edge of the creek outlet are not considered sufficiently large to consider a headland feature.

The assumed recession rate is not a significant factor with respect to the dynamic beach designation since the barrier beach is inundated by regulatory flood levels, and the Provincial Policy recommends that the Dynamic Beach Extents be defined at the toe of the barrier slope on the landward side of the barrier. The Provincial Policy indicates that the Erosion Hazard Limit is not defined for areas of Dynamic Beach; however, given the recessional nature of the adjacent reach to the east and the riverine setting landward of the barrier beach, the Erosion Hazard Limit (based on 1994 estimated recession rates) has been shown (in Appendix A) for reference purposes and for integration with river reach hazard lines.

5.4 Reach 52: Two Mile Creek Barrier Beach

The beach at the outlet of Two Mile Creek is located at the easterly end of a relatively long (1200 m ±) stretch of narrow sandy beach that spans the distance between Two Mile and Four Mile Creeks.

The 1994 shoreline management plan indicates that the barrier beach at Two Mile Creek is 100 % natural and it exhibits a representative recession rate of 0.8 m/yr. The water's edge is described as a narrow sandy beach and creek mouth with glacial material in the nearshore zone. Visual inspection of the site in late August, 2004, shows that the beach is relatively narrow with a significant amount of small cobble material. The trees along the shoreline are partially buried by the littoral materials. Typical conditions at the creek mouth are shown in **Figure 5.6**.

A review of historic aerial photographs is inconclusive at this location, with no consistent trends obvious. The barrier beach is inundated by regulatory flood levels, and classification of this beach within the Dynamic Beach Sub-Classification system would suggest a "Barrier Exposed Sand Beach" system (Sub-Class # 3-3-3). It is noted that the material at this beach was significantly coarser than that at the other dynamic beach sections within the Study area on the date of inspection.

Given the inconclusive shoreline migration trends, there is no recommended change to the estimated shoreline recession rate proposed in the 1994 Shoreline Management Report. This is not a significant factor with respect to the dynamic beach designation since the barrier beach is inundated by regulatory flood levels, and the Provincial Policy recommends that the Dynamic Beach Extents be defined at the toe of the barrier slope on the landward side of the barrier. The Provincial Policy indicates that the Erosion Hazard Limit is not defined for areas of Dynamic Beach; however, given the recessional nature of the adjacent reaches and the riverine setting landward of the barrier beach, the Erosion Hazard Limit (based on 1994 estimated recession rates) has been shown (in Appendix A) for reference purposes and for integration with river reach hazard lines.

Figure 5.6 : Looking West from Two Mile Creek Outlet

6 Significant Changes from 1994 Conditions

The present study focused on the definition of the Dynamic Beach Hazard Limits within the Study area, and as a result, these areas were reviewed in detail.

A general update of the Regulatory Hazard Limits was also completed. This update was based on a review of the updated topographic model and aerial images. The hazard lines were re-established on the basis of the most recent information available to the Study Team. The majority of the shoreline shows relatively little change since the 1994 mapping was completed; there are some areas of minor to moderate recession which are consistent with dynamic shoreline areas. In general, the shoreline recession over the last 10 years is somewhat less than that which would be predicted by the recession estimates presented in the 1994 report. This is in part due to the effect of shoreline protection works.

Two sites were noted where significant changes have occurred since the completion of the 1994 Shoreline Management Plan. These sites are discussed briefly below.

Reach 40: Butkin Drain to Eight Mile Creek
This reach is a Glacial Drift Bluff (Dillon and Atria, 1994) with an estimated annual recession rate of 2.5 m. The 1994 shoreline mapping shows the shoreline and Flood Hazard Limit to be a significant distance offshore in this area, suggesting substantial erosion of this shoreline over the last 10 years. The approximate shoreline recession rate determined on the basis of the shoreline differences between the 1994 lines and the 2002 aerial photograph image used for the present study suggests an annual recession rate of approximately 2.8 m. This reach exhibited by far the most significant change during this period, and should be considered extremely active.

Reach 46: Six Mile Creek to Firelane 6
A shoreline fill and associated protection works appear to have been constructed immediately east of Firelane 8. This fill has resulted in a marginal change in the orientation of the Hazard Limit lines in this area.

It is also expected that natural deterioration of existing shoreline structures and construction of new protection works have also occurred over this time period. This would result in some inconsistencies between current shoreline conditions and the information presented in the 1994 Shoreline Management Report with respect to the physical shoreline characteristics.

7 Regulatory Mapping

The updated Regulatory mapping is provided digitally under separate cover. Hazard limits are presented on a reach by reach basis for reference purposes in Appendix A. It is suggested that Hazard Lines should be interpreted with the following considerations in mind.

- The location of the various hazard lines has been derived on the basis of aerial photography interpretation and digital topographic modelling, and does not consider the effect of local irregularities in the physical shoreline conditions that may affect the site specific hazards. Where development is proposed, the location of the Regulatory Hazard Limits should be reviewed with regard to the most recent and detailed site information available, with due consideration to the effect of adjacent shoreline conditions and associated hazards.

- The Regulatory Flood Hazard Limit has been developed on the basis of a 100 year Regulatory Flood Limit (defined at the 177.0 m contour) with a 15 m offset to account for water related hazards.

- The Regulatory Erosion Hazard Limit has been developed on the basis of a stable slope consideration (3:1) and an offset equivalent to 100 times the estimated average annual recession rate. The effect of protection works is not necessarily well accounted for in the estimate of recession rates.

- The Regulatory Dynamic Beach Hazard Limit has been developed as per the discussion presented in Section 5 of this report.

8 References

Ontario Ministry of Natural Resources, 2001. *Great Lakes – St. Lawrence River System and Large Inland Lakes. Technical Guides for Flooding, Erosion, and Dynamic Beaches in Support of Natural Hazards Policies 3.1 of the Provincial Policy Statement.* Watershed Science Centre, Trent University.

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APPENDIX A
Shoreline Hazard Limits by Reach