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Elgin County Shoreline Management Plan

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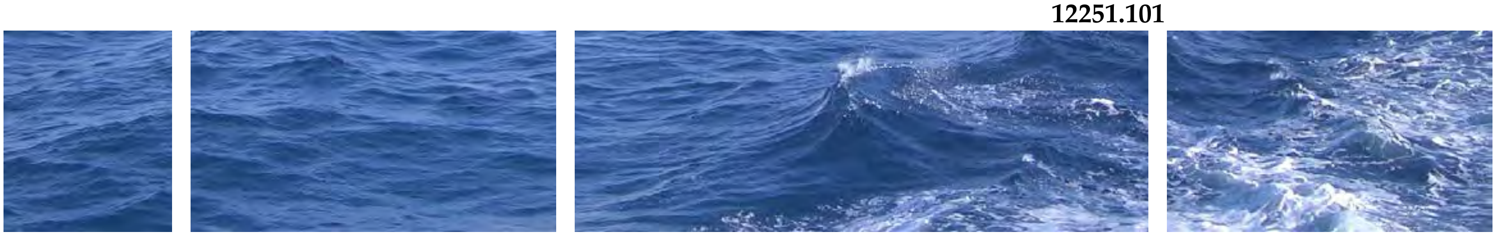

Innovation, Excellence & Service

Elgin County Shoreline Management Plan

Prepared for

Elgin County
Progressive by Nature

Lower Thames Conservation

Kettle Creek Conservation Authority

Catfish Creek Conservation Authority

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1.0 INTRODUCTION

The Elgin County shoreline is located along the north shore of Lake Erie and regulated by four Conservation Authorities (CAs). This report summarizes the rationale for the development of a joint Shoreline Management Plan (SMP) by the four CAs and the supporting technical studies. The delineation of the shoreline hazards and the recommended shoreline management approaches are also summarized. Finally, Sections 5.0 to 8.0 are dedicated to the specific hazards and recommendations for the individual CAs.

1.1 Background and Purpose of the Study

The legislative and policy framework for shoreline management across Ontario in general and in Elgin County specifically is briefly reviewed to provide the context for this investigation.

1.1.1 Ontario Provincial Policy Statement (MMAH, 2014)

The Provincial Policy Statement (PPS) recognizes that Ontario's long-term prosperity requires resilient communities supported by long-term strategic development plans, protection of natural resources, and sustainable economic growth. To ensure healthy and resilient communities, the policy statement recommends: 1) avoid development patterns that cause negative environmental impacts or safety concerns (such as developing on hazardous lands), 2) promote development in existing settlement areas to avoid unnecessary land conversions (e.g. avoid conversion of agricultural land to urban land), and 3) promote development that conserves native biodiversity.

To promote healthy active communities, the PPS recommends maintaining existing and providing new public access to our shorelines. Existing Provincial Parks, Conservation Areas and other natural areas must be protected from negative impacts associated with new development.

The linkages between the protection of Ontario's natural heritage system and long-term environmental health and social well-being are also highlighted, including the following recommendations:

- Natural features and areas (e.g. Long Point and Rondeau) shall be protected for the long term.

- The long-term ecological function and biodiversity of natural heritage systems should be maintained, restored and where possible improved.

- Development and site alterations shall not be permitted on wetlands, fish habitat or habitat of endangered and threatened species.

The importance of protecting Ontario's residents and communities from coastal hazards is outlined in Section 3.0 of the PPS. Development shall be directed away from areas of natural or human-made hazards where there is unacceptable risk to public safety, property or assets, such as buildings. Finally, development and site alterations must not create new hazards, aggravate existing hazards, or result in adverse environmental impacts.

1.1.2 Elgin County Official Plan

The Elgin County Official Plan (2012) was approved by the Ministry of Municipal Affairs and Housing in 2013. The document provides a 20 year strategic vision for managing growth and future land use decisions in the County. It is also linked to the Official Plans and Zoning Bylaws of the lower tier Municipalities and Townships, where the mapping depicting the hazardous lands as determined in this SMP is presented.

The Official Plan also provides important background information on goals for the protection of natural heritage features (wetlands, wildlife habitat and fish habitat), restoration of habitat (not degradation) in conjunction with new development, and locating future growth into existing settlement areas and away from hazardous lands, which is pertinent to this SMP.

1.1.3 Technical Guide for the Great Lakes – St. Lawrence River System and Large Inland Lakes

In 1996, the Ministry of Natural Resources and Forestry (MNRF) released the Technical Guide for the Great Lakes – St. Lawrence River System and Large Inland Lakes (MNRF, 2001a). These guidelines provide the technical basis and procedures for establishing the hazard limits for flooding, erosion, and dynamic beaches in Ontario as well as scientific and engineering options for addressing the hazards.

1.1.4 Understanding Natural Hazards (MNRF)

MNRF prepared Understanding Natural Hazards (MNRF, 2001b) to assist the public and planning authorities with explanation of the Natural Hazard Policies (3.1) of the Provincial Policy Statement of the Planning Act. This publication updates and replaces the older Natural Hazards Training Manual (from 1997).

1.1.5 Conservation Authorities Act

The Conservation Authorities Act was created in 1946 and provides the legal basis for the creation of Conservation Authorities. Section 20(1) of the Act defines the objects of an Authority, including "to establish and undertake, in the area over which it has jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources".

The Act provides further direction with respect to completing technical investigations within its watershed boundaries, including the shoreline, to support the development of a program to ensure the natural resources under its jurisdiction are conserved, restored, developed and managed.

The Conservation Authorities are also permitted, as outlined in subsection 28(1), to make regulations prohibiting, regulating, or requiring proponents to secure permission from the Authority for development, if in the opinion of the Authority the control of flooding, erosion, dynamic beaches, pollution or the Conservation of Land may be affected by the proposed development. Such lands are referred to as hazardous lands and occur adjacent to or in close proximity of the shoreline of Lake Erie, including river and stream valleys. They are unsafe for development because of naturally occurring processes associated with flooding, erosion, dynamic beaches, or unstable soil (Section 28(25)).

In 1998, the Conservation Authorities Act was amended as part of the Red Tape Reduction Act (Bill 25), to ensure that Regulations under the Act were consistent across the province and complementary to provincial policies. Significant changes were made to Section 28, which led to the replacement of the Fill, Construction and Alteration to Waterways Regulations with the current Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (MNRF/CO, 2008).

1.1.6 Ontario Regulation 97/04 (2011)

Ontario Regulation 97/04 was made under the Conservation Authorities Act described above and outlines the requirements and content for a regulation pertaining to hazardous lands (updated in 2011) for each individual CA. For the coastlines of the Great Lakes, the limit of hazardous lands is defined as the furthest landward extent of the following:

- Coastal Flooding: the 100 year flood level plus an allowance determined by the Authority for wave uprush and other water related hazards.

- Erosion: the predicted long-term stable slope measured from the existing toe of slope or from the predicted location of the toe of slope as the location may have shifted as a result of shoreline erosion over a 100 year period.

- Dynamic Beach: an allowance to accommodate dynamic beach movements over time, as determined by the Authority.

- Other Areas: an additional allowance determined by the Authority, not to exceed 15 m, can be added to the flooding, erosion and dynamic beach regulations.

- Pollution or the Conservation of Land is not affected by the proposed development.

1.1.7 Guidelines for Development Schedules of Regulated Areas

Additional technical information for establishing the boundaries of hazardous lands adjacent to the coastline of the Great Lakes are provided by Conservation Ontario and MNRF (2005) in a document entitled Guidelines for Developing Schedules of Regulated Areas. Additional technical information used to define hazardous lands and supplement the information in Ontario Regulation 97/04 is provided, including the following details relevant to this SMP:

- Coastal Flooding: in the absence of detailed technical information, the wave uprush limit is 15 m measured horizontally from the 100 year flood level;
- Erosion: the 100-year erosion allowance must be determined with a minimum of 35 years of data and in the absence of detailed site specific data, the stable slope angle is 3:1 (H:V);
- Dynamic Beach: in the absence of detailed technical information, a dynamic beach is the sum of the 100-year flood level, 15 m wave uprush limit and an additional 30 m allowance for the dynamic nature of beach movements.

1.1.8 Individual Conservation Authority Generic Regulations

The four individual Conservation Authorities have generic regulations as mandated by Ontario Regulation 97/04. The regulations are summarized in Table 1.1 by CA. These documents were reviewed to inform the updated approaches developed for this SMP.

Table 1.1 Ontario Regulations for the Individual CAs

Conservation Authority	Ontario Regulation
Lower Thames Valley Conservation Authority	152/06
Kettle Creek Conservation Authority	181/06
Catfish Creek Conservation Authority	146/06
Long Point Region Conservation Authority	178/06

1.2 Conservation of Land

While there is considerable guidance on how to define the erosion, flooding and dynamic beach hazards, as outlined in Section 1.1 of this report, there is limited explanation of the meaning and principles associated with the term “Conservation of Land”. However, Ontario Regulation 97/04 is clear that permission to develop will not be granted on hazardous lands if the Conservation of Land is impacted.

Given the lack of definition assigned to the term Conservation of Land in the Ontario Regulations and other guidance documents available to CAs, recent rulings from the Mining and Lands Commission were consulted. For example, in Russell versus TRCA (2009), the principles associated with Conservation of Land were tested with respect to a development application on regulated lands in the Don River Valley, Toronto, Ontario. The subject lands were identified for protection in the TRCA's Valley and Stream Corridor Program, and thus the proposed application for re-grading and construction of a residence came under the scrutiny for potential impacts to the Conservation of Land.

The Mining and Lands Commission, based on past precedent, developed the following definition for Conservation of Land: "to include all aspects of the physical environment, be it terrestrial, aquatic, biologic, botanical or air and the relationship between them." And though not specifically referenced in the term, the concept of ecosystem was determined to be inherent in the definition of land and thus was adopted by the Mining and Lands Commission as a principal associated with the Conservation of Land.

The Commission concluded that when evaluating the implications of a development application on the Conservation of Land, the following should be considered:

- The protection of the natural environment from harm or loss.
- The interaction of the land, its features, and its functions within the ecosystem.
- The issue of incremental and cumulative loss must be considered in decisions regarding Conservation of Land.

The relevance of this ruling by the Mining and Lands Commission and the implications for new development and shoreline protection structures are explored further in subsequent sections of this report.

1.3 Existing Studies

Shoreline Management Plans were developed by the Kettle Creek, Catfish Creek, and Long Point Region Conservation Authorities in 1989, 1991, and 1989 respectively. The Lower Thames Valley Conservation Authority completed a shoreline study (Sandwell, 1993) and has written guidance as outlined in Ontario Regulation 152/06. These operational guidelines have not been previously incorporated into a SMP.

The existing SMPs provide background information on the coastline of the CAs, describe data collection and analysis, develop a range of management actions for the coastline, and identify the preferred management approach. This SMP builds on these previous studies.

1.4 Study Limits and Approach

Elgin County is located on the north-central shore of Lake Erie in the Province of Ontario. The jurisdiction of the four Conservation Authorities fall within the boundaries of the County, including: Lower Thames Valley Conservation Authority (LTVCA), Kettle Creek Conservation Authority (KCCA), Catfish Creek Conservation Authority (CCCA), and the Long Point Region Conservation Authority (LPRCA). Refer to Figure 1.1 for a map of the jurisdictional boundaries.

Figure 1.1 Elgin County Shoreline and Conservation Authority Boundaries

Baird & Associates was retained by Elgin County and the four CAs to update their existing SMPs, which are now in excess of 20 years old. Collectively, the boundaries of the four CAs comprise a significant portion of the Long Point and Rondeau littoral cells (discussed further in Section 2.2). Shoreline erosion is a natural process along the north shore of Lake Erie and is an important source of new sand and gravel for these littoral systems. Sediment eroded from the bluffs is transported along the shore and ultimately accumulates in large depositional features along the coast, such as the Long Point and Rondeau sand spits. To maintain natural coastal processes along the north shore of Lake Erie and protect these significant natural heritage features requires a holistic regional scale approach to coastal management. The joint SMP provides the ideal framework to consider physical processes at these large scales and ensure the supply of sediment to these depositional features through natural background erosion in the future.

This collaborative recognizes the inter-connected nature of the coastline along the north shore of Lake Erie and the need to manage the coast at large spatial scales. This approach is similar to the principals of Section D2 in the Elgin County Official Plan (2012) for protecting and restoring water resources, which recognizes that watersheds are the appropriate scale for effective planning and management of issues related to water (i.e. not smaller scales such as individual property parcels).

1.5 Principles and Objectives for the Updated SMP

A series of principles and objectives were developed by the Steering Committee and Technical Advisory Committee to guide the development of this SMP. In many cases, they are consistent with the goals and objectives of the Elgin County (2012) Official Plan. They include:

Principles

- Integrated Coastal Zone Management: The SMP will attempt to balance environmental, social, cultural, recreational, and economic objectives within the boundaries of natural coastal systems, such as littoral cells. It requires information collection, planning, decision making, management, and monitoring. Policies, regulations, and stakeholder participation are reviewed to establish goals and objectives for coastal areas and take actions towards achieving them.

- Ecosystem Based Management: Management activities and decisions recognize the inter-connected nature of watersheds, coastal zones, and offshore areas for the ecosystem of interest. A holistic and collaborative approach to resource management is required to protect the ecosystem goods and services that local economies rely on for sustainable development.

- Conservation of Land: Protection and restoration of all aspects of the physical environment, including terrestrial and aquatic ecosystems, is an overarching goal of the SMP, and must not be jeopardized by future development on regulated lands and along the shoreline.

Objectives

- Maintain Natural Physical Processes Along the Coast: Natural erosion, sediment transport and depositional processes along the north shore of Lake Erie should be maintained by locating new development inland of the hazardous lands.

- Protect and Restore Coastal Habitat: The parties to the SMP should continue their efforts to protect and restore significant coastal habitat and protect endangered/threatened species, consistent with Section D1.2.1 and D1.2.5 of the Elgin County Official Plan (2012).

- Focus New Development in the Port Communities: New development applications will be directed to areas away from hazardous lands along the open coast, consistent with Elgin County`s Official Plan (2012). For example, new coastal development should be directed to existing high density nodes, such as the port communities of Port Glasgow, Port Stanley, Port Bruce, and Port Burwell, where existing municipal utilities are available and the shoreline hazards have been mitigated.

- No Negative Impacts for New Development: New development must not have a negative impact on existing development or the coastal ecosystem, including terrestrial or aquatic habitat. It must not create new or exasperate existing coastal hazards, near, or far field.

- Standardized Interpretation of the SMP: The principles and regulations outlined in this SMP will be uniformly interpreted and applied across Elgin County by the four Conservation Authorities.

- Regular Communication of Coastal Hazards: The mapping and technical studies completed to update the SMP will be leveraged to communicate coastal risks to riparian land owners by Elgin County, the local Municipal governments, and the Conservation Authorities.

- Maintain Public Access to the Coastline in the Port Communities: Recognizing the importance of a public and accessible coastline for recreational, health and spiritual pursuits, all parties with a role in land use management in Elgin County will strive to maintain and enhance public access to Lake Erie in the Port Communities.

2.0 TECHNICAL ANALYSIS

Section 2.0 describes the field observations, Lake Erie littoral cells, the updated recession rate calculations, a review of lake level extremes, and geotechnical considerations for the coastal bluffs.

2.1 Field Observations

The Elgin County shoreline was traversed from the west to east boundary from July 14^{th} to 16^{th}, 2014. A total of 51 sites were visited, as noted in Figure 2.1. At each location GPS coordinates were collected, along with digital photographs and video, field notes on site observations, plus records of discussions with stakeholders. In some locations the shoreline was not accessible due to the fragmented nature of the local road network or the absence of a land-owner to grant site access.

The first site visited was the Enchanted Hideaway Campground in West Elgin, southwest of Port Glasgow. The site features an eroding high bluff, which is typical for the LTVCA portion of the shoreline, as seen in Figure 2.2. The concrete slab in the lower left corner of Figure 2.2 is from an abandoned shuffle board deck. In discussions with one of the campground residents (Bill, Site 234), it was noted that slope failures are often associated with heavy rainfall events.

One of the access roads within the campground runs adjacent to the eroding bluff crest (Figure 2.2). The road is located at the bluff crest and in a zone of imminent failure. For example, the next bluff failure could consume the entire road, and such a failure could happen at any time. Any buildings or vehicles in close proximity to the bluff crest could be damaged or completely lost. More importantly, since there is often no warning of such a failure, there may not be sufficient time to exit a threatened building during a slope failure. The result could be serious injury and loss of physical assets.

Pictures of typical eroding high bluff sites in the three other CAs are provided Figure 2.2. In addition, photographs of the other study sites are provided in subsequent chapters of this SMP.

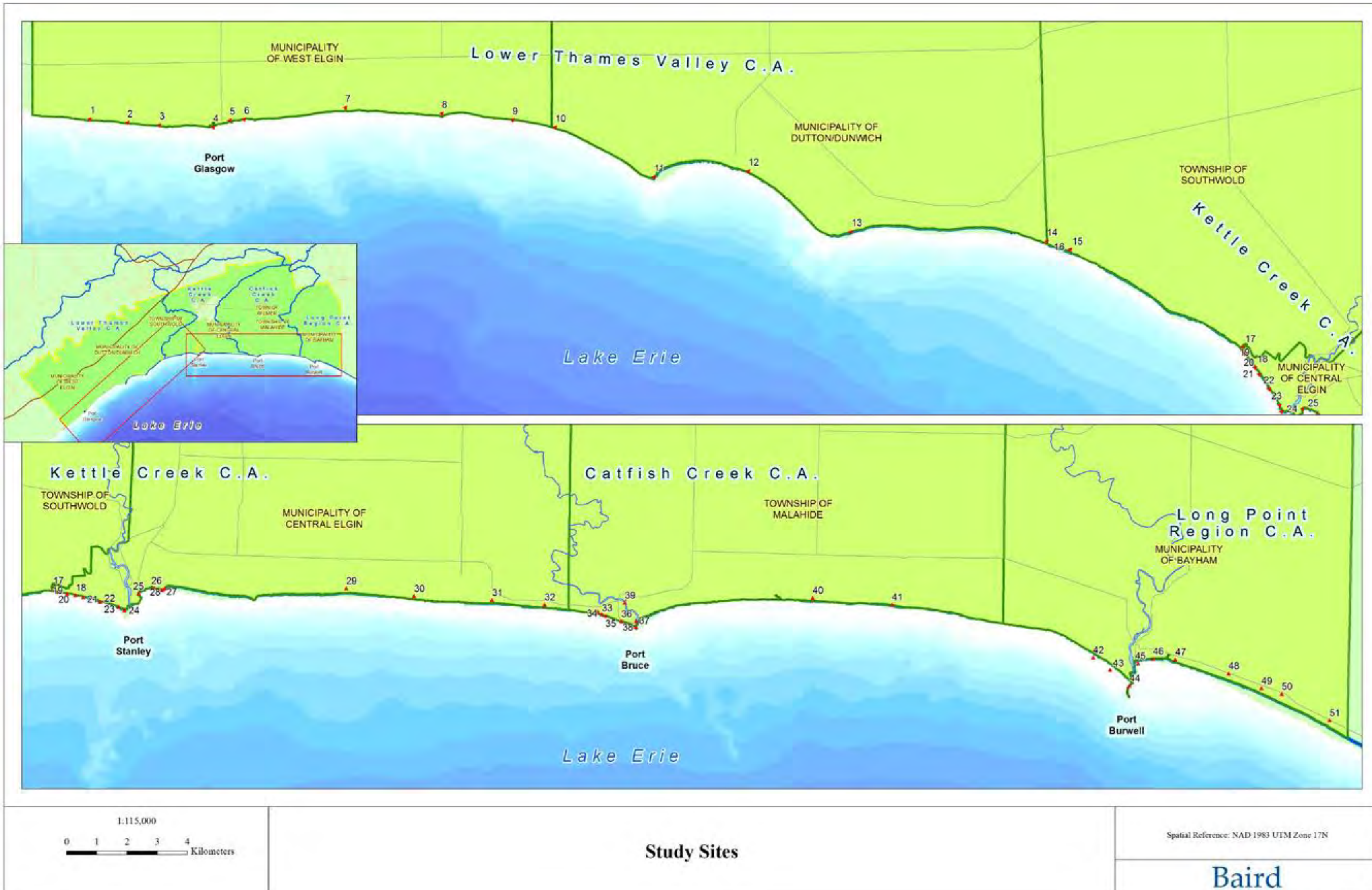


Figure 2.1 Map of July 2014 Study Sites

TYPICAL ERODING BLUFFS FROM WEST TO EAST

Site 1: Eroding High Bluff (LTVCA)

Site 1: Road Along Bluff Crest (LTVCA)

Site 16: Eroding High Bluff (KCCA)

Site 16: Abandoned Foundation (KCCA)

Site 40: Eroding High Bluff (CCCA)

Site 40: Debris from Bluff Failure (CCCA)

Site 48: Eroding High Bluffs (LPRCA)

Site 48: Failure Debris (LPRCA)

Figure 2.2 Typical Eroding High Bluff Sites

2.2 Lake Erie Littoral Cells

A littoral cell is a conceptual shoreline compartment, boundary or zone defined by the supply, transport, and deposition of sand and gravel. Within a littoral cell, there is an updrift supply area, a net direction of longshore sediment transport (LST), a downdrift depositional area, and no (or only minimal) leakage of sediment at the cell boundaries. The littoral cell boundaries for the north shore of Lake Erie were defined in 1988 (Reinders) and are reproduced in Figure 2.3.

The importance of managing our Great Lakes coastlines within the boundaries of littoral cells was recently documented in an Environment Canada (2014) White Paper on nearshore water quality and ecosystem health. The paper highlighted the benefits of adopting littoral cell boundaries to develop management plans for the protection of our coastal ecosystems and the limitations of the status quo, which relies on geo-political or watershed boundaries.

To explain the inter-connected nature of coastal processes and habitat, a descriptive model of a conceptual littoral cell on the Great Lakes was developed (Figure 2.4). This model is adapted from Davidson-Arnott (1990) and has been enhanced to include the three primary shore types found in the Great Lakes, namely sandy, cohesive, and bedrock shorelines.

Davidson-Arnott (1990) estimated that approximately 40% of the lower Great Lakes (Ontario, Erie and Huron) have evolved through erosion of relatively weak Quaternary glacial, glacio-fluvial, and glacio-lacustrine sediments. Collectively, these shore types are referred to as cohesive shorelines and make up the majority of the Elgin County coast. The relative percentage of the bedrock and sandy shore types varies lake to lake.

The physical processes that control the long-term evolution of these three primary shore types are fundamentally different (Philpott, 1984; Bishop et al., 1992) and the conceptual littoral cell in Figure 2.4 provides the ideal framework to explain these differences. Shoreline erosion, sediment transport, and deposition processes are also described.

Figure 2.3 Lake Erie Littoral Cells (Reinders, 1988) Noted by Alternating Red and Yellow Arrows

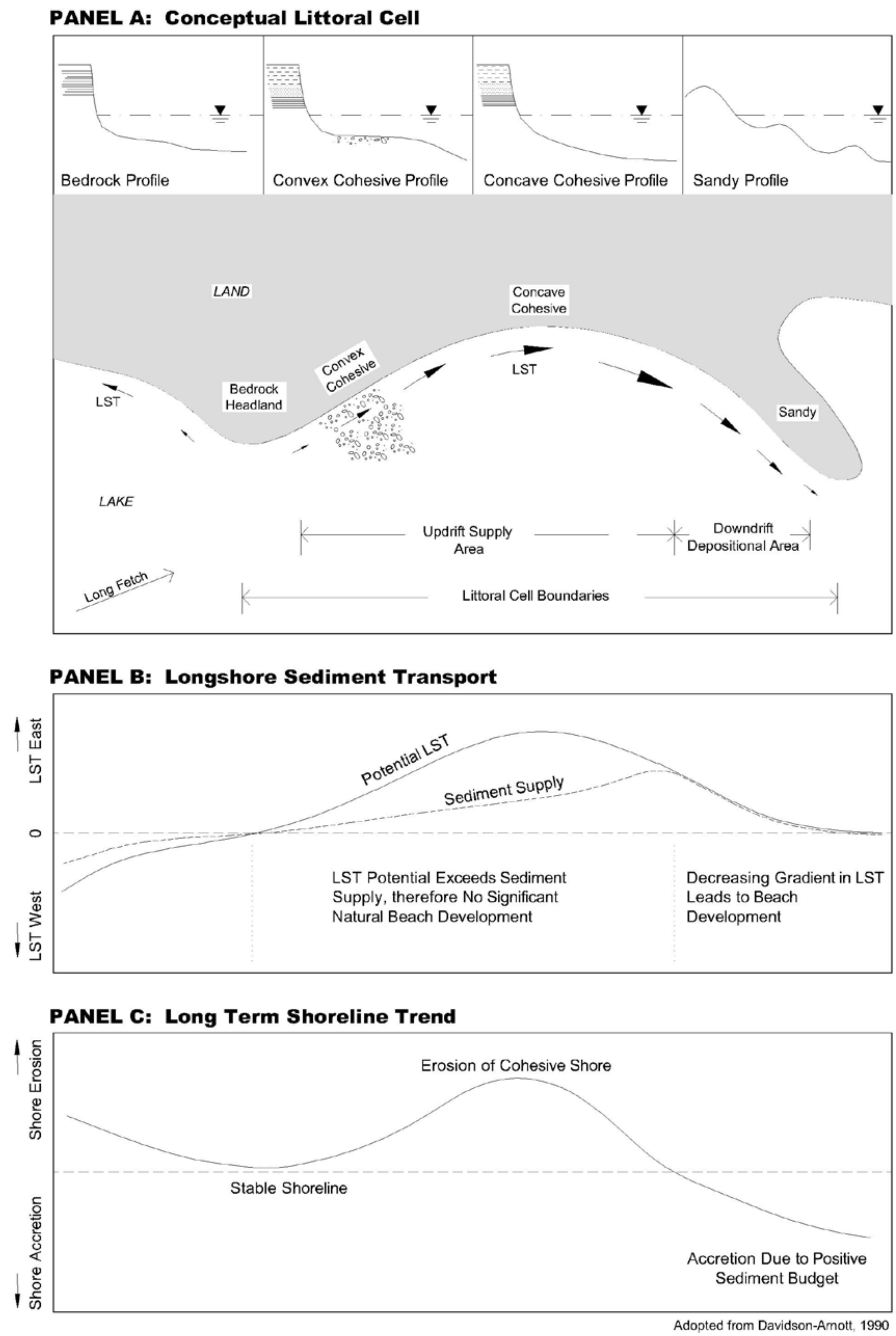


Figure 2.4 Descriptive Model of a Conceptual Littoral Cell for the Great Lakes

2.2.1 Bedrock Shorelines

Figure 2.5 presents an alongshore view of a typical bedrock shoreline, located on the south shore of Lake Erie, east of Presque Isle (Baird, 2000). The nearshore lakebed and bluff toe have developed in weak shale and limestone. The shale is capped with glacial till, clay and sand. The eroding bluff face is void of vegetation, with the exception of fallen trees from the tablelands. While there are no major bedrock exposures along the shoreline in Elgin County, they are prevalent in the eastern basin of the lake. Therefore, the role of this shore type on littoral cells is reviewed.

Figure 2.5 Typical Eroding Bedrock Shoreline (capped with cohesive sediment)

The mechanical forces of wave action in the nearshore and wave attack at the base of these bedrock cliffs are the primary mechanism leading to shore platform development and bluff erosion (Sunamura, 1992; Trenhaile and Mercan, 1984). The key physical processes associated with erosion of the lake bed and cliffs are: air compression in joints and crevices; the generation of high shock pressures by breaking waves; abrasion by rock fragments, sand and gravel; frost action; expansion due to freezing; and temperature-dependant wetting and drying (Hudec, 1973; Sunamura, 1992).

Toe erosion by waves over-steepens the slope, leading to geotechnical instabilities and mass movements such as falls, topples, slides, and flows (Sunamura, 1992). The rate of cliff retreat is related to the assailing forces of waves and the resisting force of the bedrock materials. At any given site, the relationship between the driving and resisting forces will determine the long-term rate bluff retreat.

Although bedrock shores are erodible under direct wave attack and other physical / chemical processes, they are generally more erosion resistant than cohesive and sandy shorelines. In Panel A of the descriptive model (Figure 2.4), a bedrock outcrop at lake level has resulted in the development of a prominent headland feature, since the adjacent cohesive shoreline is eroding faster. The direction and magnitude of LST rates at the headland are presented by the arrows in Panel A. Due to the combined effect of the headland and local wind patterns, a divergent node in LST exists. In other words, east of the headland, sediment is transported to the east and west of the headland, sediment is transported to the west. There is no exchange of sediment from one side to the other, thus this region represents a littoral cell boundary. Also, since the potential for waves and currents to transport sediment east and west of the divergent node is greater than the supply of new material from erosion of the bedrock shore, beaches are narrow or non-existent.

2.2.2 Cohesive Shorelines

A shore is defined as cohesive when erosion of the consolidated shore materials, such as glacial till and glacio-lacustrine deposits, is the dominant process that shapes the morphology of the shoreline (Nairn and Holmes, 1988). Underneath any cohesionless deposits (i.e. sand and gravel), there is an erodible cohesive substratum, and the erosion of this material is the primary driving force that determines how and at what rate the shore evolves. Once the consolidated material is eroded, it cannot reconstitute itself in the energetic coastal environment, and therefore, cohesive shoreline erosion is irreversible. Since the fraction of sand and gravel is generally in the range of 5 to 25% of the soil matrix (Davidson-Arnott and Ollerhead, 1995), the volume of bluff erosion is not balanced by an equal amount of nearshore deposition. Intermittent deposits of sand and gravel may accumulate on the beach and in sand bars, while the remaining fine sediment (i.e. silts and clays) is transported in an offshore and alongshore direction (Bishop, et al., 1992). The majority of the study area is cohesive shoreline. A typical eroding cohesive bluff east of Port Glasgow is presented in Figure 2.6.

Figure 2.6 Eroding Cohesive Bluff (Site 6, east of Port Glasgow)

Prior to the 1980s, research on cohesive shore erosion focused on sub-aerial bluff processes, such as failure mechanisms (Gelinas and Quigley, 1973; Quigley et al., 1976). There was limited research into the processes governing subaqueous erosion of the cohesive lake bottom in the Great Lakes. Sunamura (1983) presented a conceptual model to describe the process of cliff erosion, which relates erosion to the "assailing forces" that attack the bluff toe. When the assailing forces are greater than resisting forces the bluff toe erodes; the slope becomes progressively steeper, ultimately leading to a failure and top of bank retreat. The mechanisms of lakebed erosion were not included in Sunamura's model.

Based on detailed cross-shore lakebed measurements in depths ranging from 1 to 7 metres for a western Lake Ontario site, Davidson-Arnott (1986) reported annual downcutting rates that averaged 11 mm/yr in 6.4 m of water to 35 mm/yr in 2.3 m of water. Over periods of only a few months, lakebed erosion rates exceeded 70 mm in several locations close to shore. The downcutting was attributed to several factors, including: erosion by shear stresses associated with wave orbital motion, turbulence due to breaking waves, abrasion of the till surface by the movement of sediment particles, and softening of a thin surface layer by cyclic loading and unloading of the till surface due to the oscillatory nature of the wave motions. With these findings the model of Sunamura (1983), which attributed shore erosion primarily to wave attack at the bluff toe, was no longer suitable for the cohesive shorelines on the Great Lakes.

Philpott (1983) reported on the analysis of historic profile data from 1898 to 1979/80 for the north shore of Lake Erie, east of Port Burwell, that also documented substantial lakebed downcutting in the nearshore zone. The results showed that the downcutting rates were greater close to shore and the profile geometry remained relatively unchanged as the shore receded in a landward direction over time, which was similar to the findings of Davidson-Arnott (1986). The pattern appeared to suggest that a typical form will develop for wave cut platforms in cohesive sediments and was likely related to the pattern of wave energy dissipation in the surf zone (Philpott, 1983). Kamphuis (1987) also noted that cohesive profiles maintained a concave form and found that the geometry could be represented by the equilibrium profile concept described by Dean (1977). The profile shape is based on the equation $Y=Ax^{2/3}$ where Y is the vertical depth measured from the waterline, x is the horizontal distance measured lakeward of the waterline, and A is a shape factor related to the sediment properties.

With the above mentioned studies, the concept of an equilibrium lakebed profile that maintained a distinct concave form while the entire profile shifted in a landward direction was gaining widespread acceptance (Nairn, 1986; Coakley, 1986). However, the physical processes responsible for downcutting and accelerated rates in the nearshore were less clearly understood.

Nairn et al. (1986) presented a 2D surf zone energy dissipation model that empirically relates downcutting of the cohesive profile to two processes: 1) shear stresses on the bed due to wave orbital velocities; and 2) turbulence at the surface layer due to breaking waves which penetrate to the bed. The amount of turbulence that reaches the bed in a cross-shore direction is related to the gradient in wave energy dissipation across the surf zone. With the addition of turbulence related to wave breaking and plunging breakers, the model is capable of reproducing the observations from field measurements, which indicate increased downcutting in an onshore direction (Nairn et al., 1986; Bishop, et al., 1992).

The cohesive profiles of the Great Lakes often feature sand and gravel deposits in the form of beaches at the toe of the bluff, scattered across the lake bed in intermittent deposits and accumulations in sand bars (Kamphuis, 1987). Field observations have highlighted the mobility of these sediments in response to waves and currents (Davidson-Arnott, 1986; Davidson-Arnott and Ollerhead, 1995). If the cohesionless sediment in the nearshore and on the beach is of sufficient thickness, it can protect the underlying cohesive substratum from erosion. To provide protection, the sediment thickness must permanently cover the underlying cohesive sediment and be thicker than the active layer that is re-distributed by waves and currents during storms. Therefore, the required thickness of sediment will vary based on water depth, the profile geometry, slope, sediment characteristics, and the local wave climate. Thick deposits of sand are rarely found in the Great Lakes, with the exception of sites against a littoral barrier, such as a natural headland or engineered navigation channels. Along the Elgin County shoreline, the only locations with significant sediment deposits are the beaches adjacent to the jettied river mouths.

When the sediment cover above the cohesive lakebed is only a thin veneer, and it is entrained in hydraulic flow during storms, the sediment acts as an abrasive agent and accelerates the downcutting rate (Davidson-Arnott and Ollerhead, 1995). The influence of sand has also been studied in the laboratory with field samples of glacial till (Kamphuis, 1990; Nairn, 1986; and Bishop et al., 1992). The lab findings also suggested that the presence of sand in the eroding stream, whether along the bed or entrained in breaking waves, plays a significant role in the erosion rates of the cohesive lakebed.

A second important consideration when evaluating sediment cover above the cohesive substratum is the mobility of the material over various temporal scales (i.e. single storm events to several decades). Davidson-Arnott and Ollerhead (1995) presented field measurements of lake bed downcutting that suggest the mobile sediment at the edges of bar features can accelerate erosion, while the bar provided a sufficient protective cover to dampen wave energy and eliminate erosion. However, if the bar position remains static, this finding is at odds with the observation that the cohesive profile maintains an equilibrium form as it migrates in a landward direction.

Long-term water level trends or cycles on the Great Lakes provide insight to the mechanism for bar migration in a cross-shore direction. Consider the long-term monthly mean water levels for Lake Erie, which are presented later in Section 2.5. The trend of rising and falling lake levels moves bar features in an onshore and offshore direction (Hands, 1979). As the bar features move up and down the profile, new sections of lakebed are continually exposed to erosion, which ultimately allows the entire lakebed to erode and maintain an equilibrium form (Nairn et al., 1997; Davidson-Arnott and Langham, 2000).

Fieldwork on Lake Ontario highlighted the important role of lakebed softening on the long-term downcutting of the cohesive lakebed (Davidson-Arnott and Langham, 2000). A significant vertical gradient in shear strength was documented for samples extracted from the lakebed and tested in the lab. As the moisture content decreased with depth, the shear strength of the cohesive sediment increased. This leaves the surface of the lakebed susceptible to softening under pressure fluctuations due to wave orbital motion. The process appears to be most relevant offshore of the breaker zone, where there is less sand and gravel present to cause erosion by abrasion (Davidson-Arnott and Langham, 2000).

The description of cohesive lakebed erosion, summarized in Figure 2.7, highlights the key processes responsible for the downcutting and retreat of the cohesive profile. In the long-term, the continuous downcutting of the nearshore profile leads to the retreat of the bluff face. This process response sequence has been referred to as dynamic equilibrium by Davidson-Arnott (1990). As noted by Boyd (1986), the equilibrium is rarely, if ever, achieved or maintained for long periods of time. Within Elgin County, the continuous erosion of the lake bottom is what sustains the long-term erosion rates of the bluff shoreline.

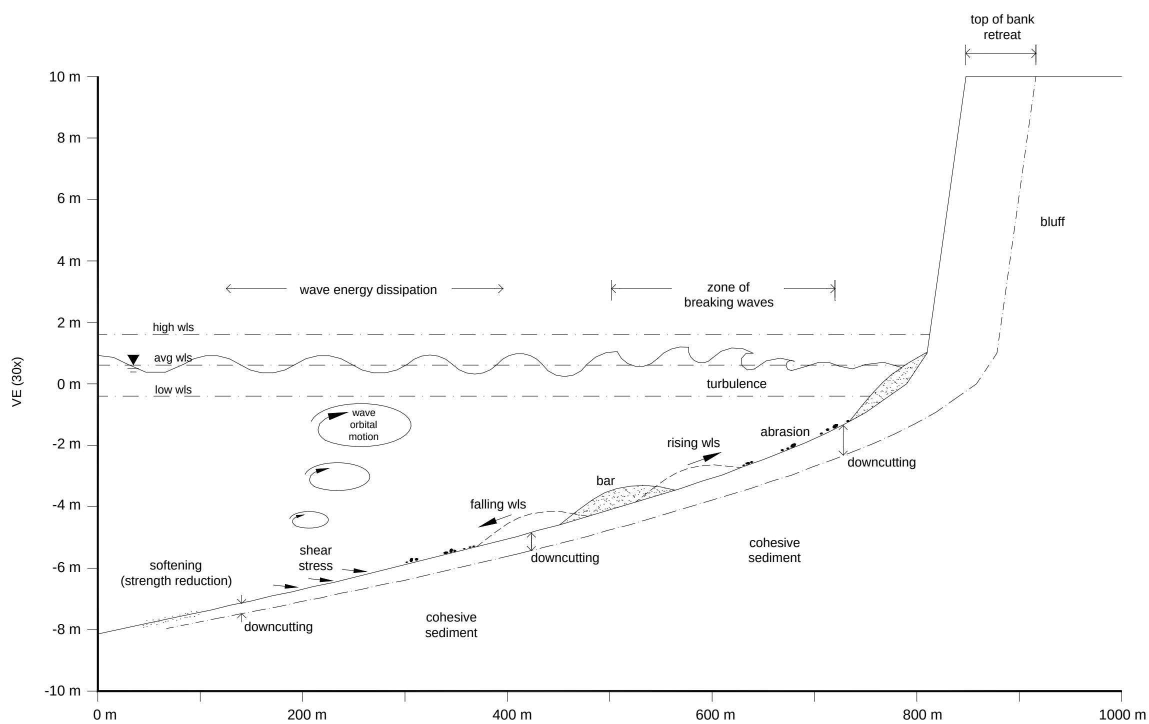


Figure 2.7 Lakebed Downcutting and Retreat of the Equilibrium Profile (Profile shape based on $Y=Ax^{2/3}$)

In reality, the retreat of the coastal bluffs is a far more complicated process than the landward shift of the equilibrium profile due solely to lakebed downcutting. Toe erosion by wave forces prevents the bluff from attaining a long-term stable slope (Trenhaile, 1987; Sunamura, 1991) and is also a key sustaining erosion process. Without the continuous removal of the slumped debris at the back of the beach, the bluff slope would ultimately attain a long-term stable angle and erosion at the bank toe would stop. However, along the open coastlines of the Great Lakes, this stability is never attained in the long-term due to the combination of wave attack and lakebed downcutting.

Mechanical weathering processes, such as freeze-thaw, ice formation, wet-dry cycles, and desiccation have been shown to be critical factors affecting the loss of compressive strength and resulting surface degradation for coastal bluffs (Trenhaile and Mercan, 1984; Boyd, 1986; Carter and Guy, 1988; Amin and Davidson-Arnott, 1995). With the expansion of fractures and the creation of loose fragments on the weathered surface, the exposed materials at the toe eventually lose their cohesive properties and are easily eroded by waves.

The physical factors that lead to toe erosion and removal of slumped debris will vary considerably depending on the stratigraphy of the site and the resistive properties of the toe sediments. Several processes have been identified, including: abrasion due to sediment entrained in waves and wave uprush; hydraulic and pneumatic pressures; turbulence due to wave breaking; and compression, tension, and cavitation (Carter and Guy, 1988; Amin and Davidson-Arnott, 1995). An example of toe erosion at the base of a cohesive bluffs east of Port Bruce is provided in Figure 2.8.

Figure 2.8 Toe Erosion due to Wave Attack (east of Port Bruce)

The site geology and geo-technical properties of the bluffs play a key role in the type of bluff failures due to wave induced toe erosion. For homogeneous bluffs, oversteepening at the bluff toe will ultimately lead to mass wasting events, such as block failures, debris flows, and shallow translational slides (Carter and Guy, 1988; Amin and Davidson-Arnott, 1995). For composite bluffs that feature complex stratigraphy and perched aquifers, toe erosion, in combination with softening, loss of effective stresses, high pore water pressures, and piping can lead to deep seated rotational failures and major landslides (Quigley et al., 1976; Eyles et al., 1986; Chase et al., 1996; Sterret and Edil, 1982). A picture of a massive rotational failure at Site 48 east of Port Burwell is provided in Figure 2.9.

Figure 2.9 Debris from a Massive Bluff Failure East of Port Burwell

Additional slope erosion processes include rain splash, overland flow, rill and gully erosion, and mudflows (Boyd, 1986; MNRF, 2001a; Buttle and von Bulow, 1986; and Burkard and Kostaschuk, 1997). Figure 2.10 summarizes some of the key erosion processes for cohesive bluffs.

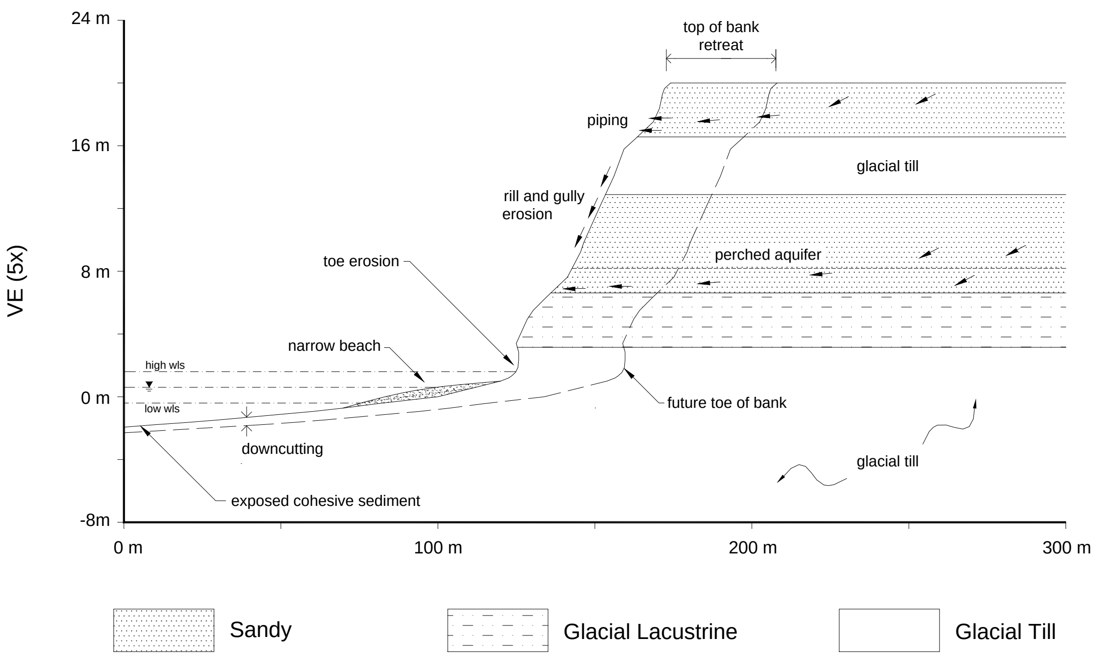


Figure 2.10 Typical Cohesive Bluff and Erosion Processes

2.2.3 Sediment Supply and Transport Along the Coast

With reference to the conceptual littoral cell in Figure 2.4, the eroding cohesive shores are important supply areas for new littoral sediment (i.e. sand and gravel). East of the bedrock headland, the nearshore cohesive profile is armoured with a cobble-boulder lag deposit (refer to the profile in the inset window of Panel A). With the landward retreat of the shoreline, the cobbles and boulders in the soil matrix naturally armour the nearshore profile, reduce downcutting rates, and eventually lead to the development of a wide shelf. The nearshore at Duttona Beach and Plum Point feature this type of lag deposit, which explains why these two headlands exist (i.e. the lake bottom and shoreline erodes slower than the bluffs formed in the adjacent cohesive sediment). In the centre portion of the conceptual littoral cell, the lakebed profile features a concave shape described by the equilibrium profile (refer to inset in Panel A) and is actively eroding. The concave profile shape is typical for the lakebed conditions found within the majority of the study area.

For the updrift supply area in Panel A of Figure 2.4, the dominant fetch is from the Southwest, which results in a net easterly directed LST rate. The potential LST rate is presented in Panel B, along with the actual supply of sand and gravel from bluff erosion. Due to the low percentage of sand and gravel in the eroded cohesive material (i.e. from the lake bed and bluffs), there is insufficient sediment in the nearshore and along the beach to meet the potential LST rate. Therefore, any new material from erosion of the cohesive shore is transported to the east in the conceptual littoral cell. Along the bluffs, sediment accumulation is limited to deposits in narrow beaches and in nearshore sand bars. Panel C details the long-term erosion rate, with stable conditions at the bedrock headland defining the cell boundary and increasing erosion rates in the supply area as the potential LST rate increases and the protective sand cover diminishes.

2.2.4 Depositional Environments in Littoral Cells

Over thousands of years erosion of the Great Lakes coastline has provided sediment for many important depositional environments and the unique habitat they support, including the sand dunes and beaches of Pinery Provincial Park and Ipperwash on Lake Huron, extensive barrier beaches that shelter the coastal wetlands at Point Pelee National Park, and the large sand spits at Rondeau Provincial Park and Long Point on Lake Erie, to mention a few examples on the Canadian shores of the lower lakes.

These depositional beach environments and the unique terrestrial and aquatic habitat they support are biodiversity hotspots in Ontario. They support unique native plant communities and in many cases represent the remaining habitat for rare, threatened, and endangered species. Given the dominance of agricultural land uses in southern Ontario, they also provide critical habitat for migratory birds. For example, with its location at the confluence of the Mississippi and Atlantic flyways, Point Pelee National Park serves as a critical staging area for more than 370 bird species during the spring and fall migration across Lake Erie (Baird, 2009). However, shoreline development and armouring of the littoral cell between the mouth of the Detroit River and the sandy western shore of Point Pelee National Park has permanently eliminated 87% of the sand supply needed to build and maintain the protective beaches that shelter the wetlands (Baird, 2008). Accumulation of the remaining sediment moving along the coast at the Kingsville and Leamington harbours has reduced the supply of sediment to the depositional portion of the littoral cell (the western shore of Point Pelee National Park) to almost zero.

The updrift supply for the littoral cell in Panel A (Figure 2.4) includes the eroding cohesive shores east of the bedrock headland. The dominant incident waves are from the southwest and result in a net LST direction to the east (arrows in Panel A). However, as seen in Panel B, the potential for LST along the cohesive section of the littoral cell exceeds the sediment supply from erosion of the shoreline (bluffs and lake bottom). Consequently, beach development and sediment accumulation in the nearshore is minimal along the updrift supply area and this is consistent with the high bluff shoreline within Elgin County. Refer to Figure 2.11 for a picture of the eroding bluffs west of Port Bruce; there is no sand beach. A piece of asphalt in the bottom of the picture is all that remains from the former access road to the beach at this location. While the bluffs are actively eroding in this region of the Catfish Creek CA, there is no beach deposit at the base of bluff since the potential transport rate exceeds the supply of new sand and gravel from erosion.

Figure 2.11 Eroding Cohesive Shore West of Port Bruce

Along the eastern third of the littoral cell in Panel A, the shoreline orientation slowly changes to a northwest to southeast direction, and is aligned approximately normal to the incident angle of the dominant waves from the southwest. There are two important and related responses to this change in shoreline orientation within the littoral cell: 1) the potential for the incident waves to generate longshore currents and transport sediment along the shoreline starts to decrease and eventually approaches zero when the waves are normal to the orientation of the beach (Panel B); and 2) with the shoreline trend switching from erosion to accretion (Panel C), there is no new sediment produced from shoreline erosion and the decreasing gradient in LST leads to beach development (Panel B). In the conceptual littoral cell model in Figure 2.4, the decreasing gradient in LST leads to the development and growth of the sand spit. For Elgin County, the Long Point sand spit is the depositional portion of the littoral cell (refer to Figure 2.12). Erosion of the coastal bluffs and transport of the sand to the east over the centuries has resulted in the formation of the successive beach ridges, which in turn support the coastal wetlands on the north side of the spit and inside Long Point Bay. Without the continued supply of sand from the updrift supply area of the littoral cell, the shoreline trend at the Long Point sand spit would switch from stable or deposition to erosion. Ultimately this erosion would destabilize the wetland habitat which is critical to the coastal ecosystem.

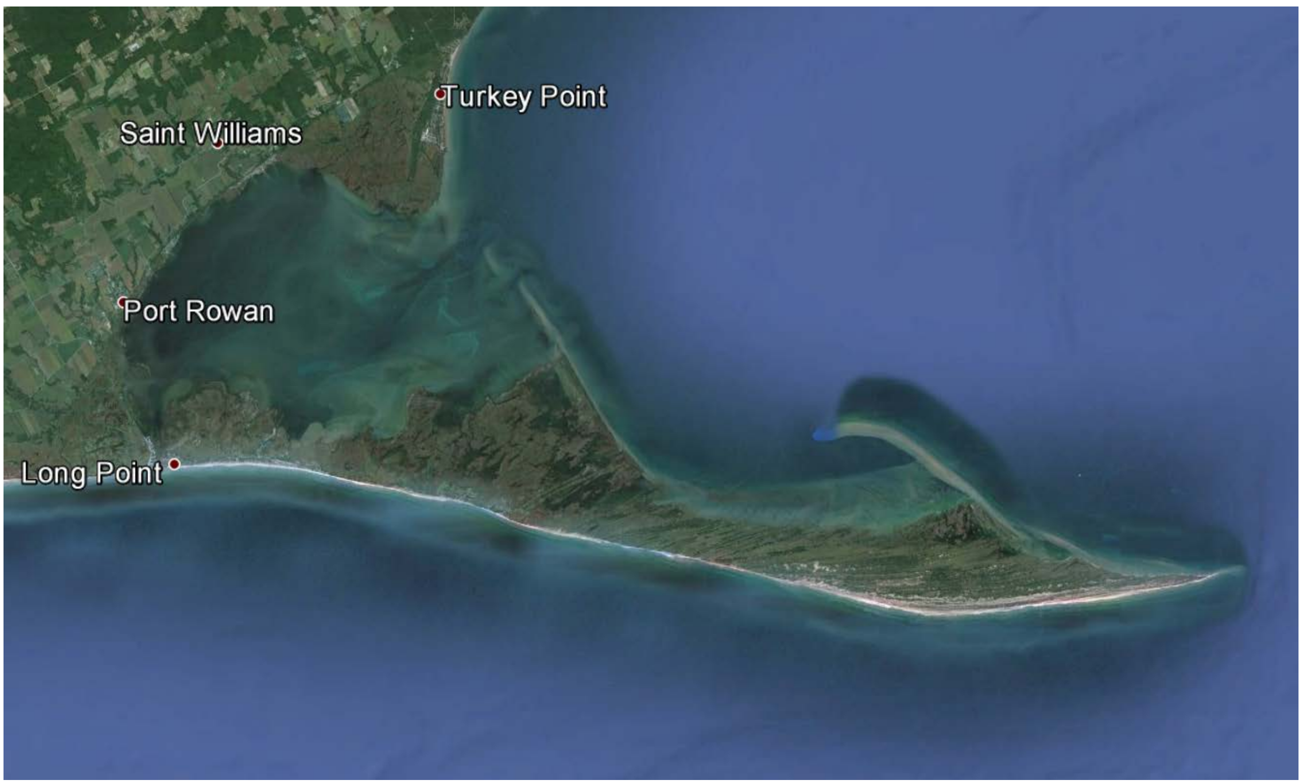


Figure 2.12 Long Point Sand Spit (depositional portion of the littoral cell)

In summary, the boundaries of the conceptual littoral cell define all sediment sources (i.e. from erosion), the major sediment transport pathways, and the deposition environment. These physical units (cells) provide the ideal scale for coastal management planning in the Great Lakes, since they encapsulate all of the key physical processes that shape our coastlines. They also highlight the importance of natural background erosion rates on the development and maintenance of our critical depositional features, such as the Rondeau and Long Point Sand Spits.

2.3 Shoreline Reaches

The study area, as defined by the spatial extent of the Elgin County shoreline, represents approximately 90 km of Lake Erie coastline. In order to quantify coastal hazards and establish suitable management objectives, the shoreline was sub-divided into a series of reaches that featured similar geologic and geomorphic conditions, land use patterns, and exposure to coastal hazards. The boundaries were further refined based on the field observations, including site specific conditions at 51 sites. This delineation of shoreline reaches is consistent with the approach adopted in the existing SMPs for the LPRCA, KCCA, and CCCA, where the shoreline was subdivided and suitable management approaches were developed.

The primary shoreline reach types are summarized and depicted visually in Figure 2.13:

- High Bluff: Eroding cohesive bluffs found between the port communities. Beaches are narrow or non-existent, especially during average to high lake level periods. The bluff shorelines are typically found in the updrift supply area of a littoral cell and feature a long-term erosion rate.

- Large Beaches: Large beach deposits within the study area are found on the east and west side of the jettied navigation channels in the port communities. These beaches are depositional environments due to the trapping potential of the jetties and stable in the long-term. These beaches are also found on low lying lands susceptible to coastal flooding hazards.

- Port Lands and Navigation Channel: The commercial port lands are serviced by a navigation channel to the lake and stabilized with engineering structures, such as steel sheet pile walls, and quarried armour stone breakwaters. Much of the traditional commercial activities have been replaced by recreational boating and other tourism activities.

- Residential Development in the Port Communities: Intense urban development is found along the shoreline of the port communities. Since these shorelines eroded naturally prior to European settlement, the water's edge is typically armoured with a wide range of existing shoreline protection structures of variable quality.

Typical High Bluff Shoreline

Beach Shoreline

Navigation Channel Leading to a Marina

Port Community

Figure 2.13 Shoreline Type for Reach Delineation

2.4 Recession Rates

Section 2.4 reviews published historical recession rates for Elgin County and measurements completed specifically for this SMP.

2.4.1 Published Historical Rates (Fleming 1983)

A comprehensive erosion rates analysis was completed for the north shore of Lake Erie (Fleming, 1983), stretching from Rondeau in the west to Long Point in the east. Survey data from 1936/37 was compared to survey data from 1968/71/75 at 100 m transects along a baseline generally parallel to the coastline. The calculated annualized recession rate (m/yr) is presented in Figure 2.14. The rates increase from Rondeau in the west (approximately 10 km on the x-axis in Figure 2.14) to Long Point (approximately 120 km on the x-axis). The report discusses the spatial variability in the data and attributes it to a number of possible factors, including temporal and spatial variability in bluff failure mechanisms. A 51 point rolling mean was ultimately applied to smooth the data for further analysis by Fleming (1983).

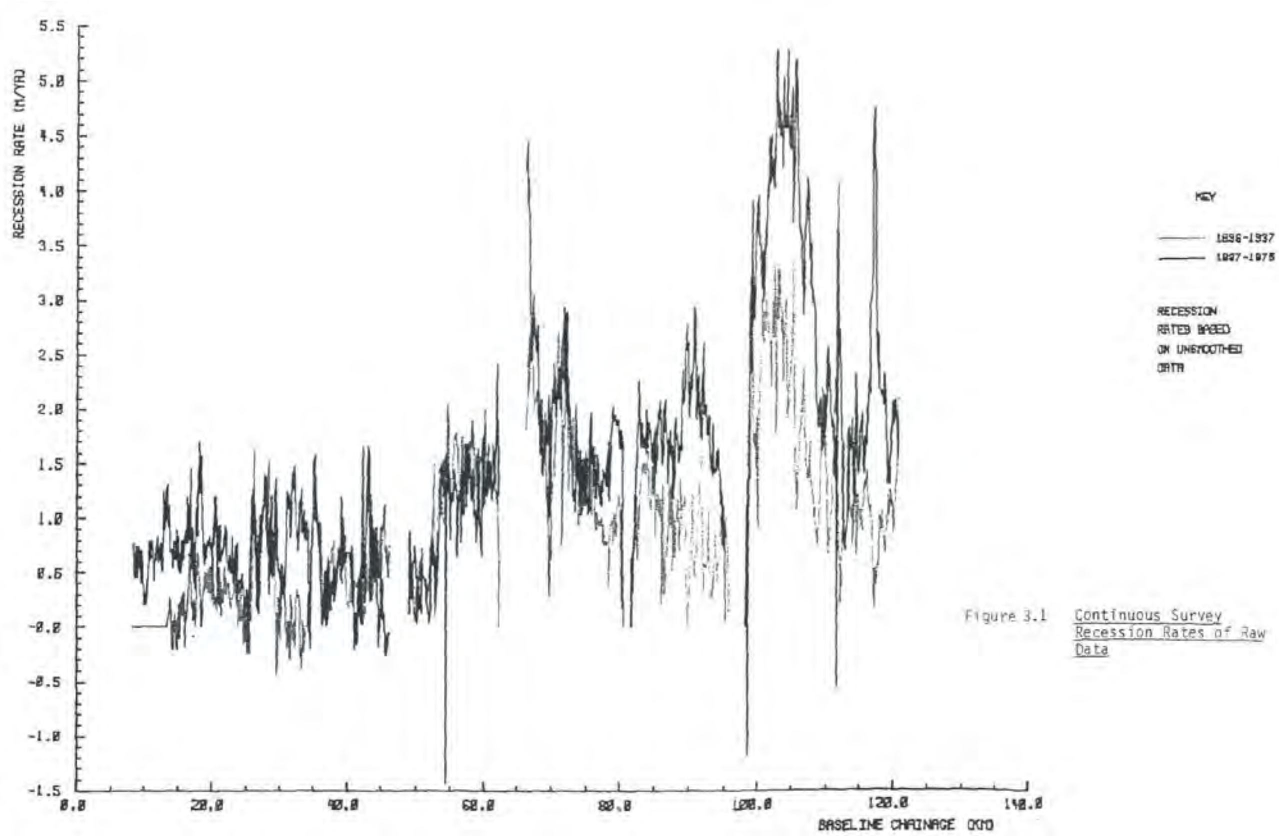


Figure 2.14 Annualized Recession Rate Data from Fleming (1983)

Baird re-created the Fleming (1983) baseline using Geographic Information System (GIS) software and subdivided the line into 100 m increments. Then the recession rates for the individual 100 m transects were added to the baseline. Refer to Figure 2.15 for a map of the baseline east of Port Stanley. The recession rates are colour coded based on 1 m increments. The high bluffs immediately east of Port Stanley were eroding at greater than 3.0 m/yr between 1936/37 and 1968/71/75. The rates decrease slightly towards the present location of the water intake.

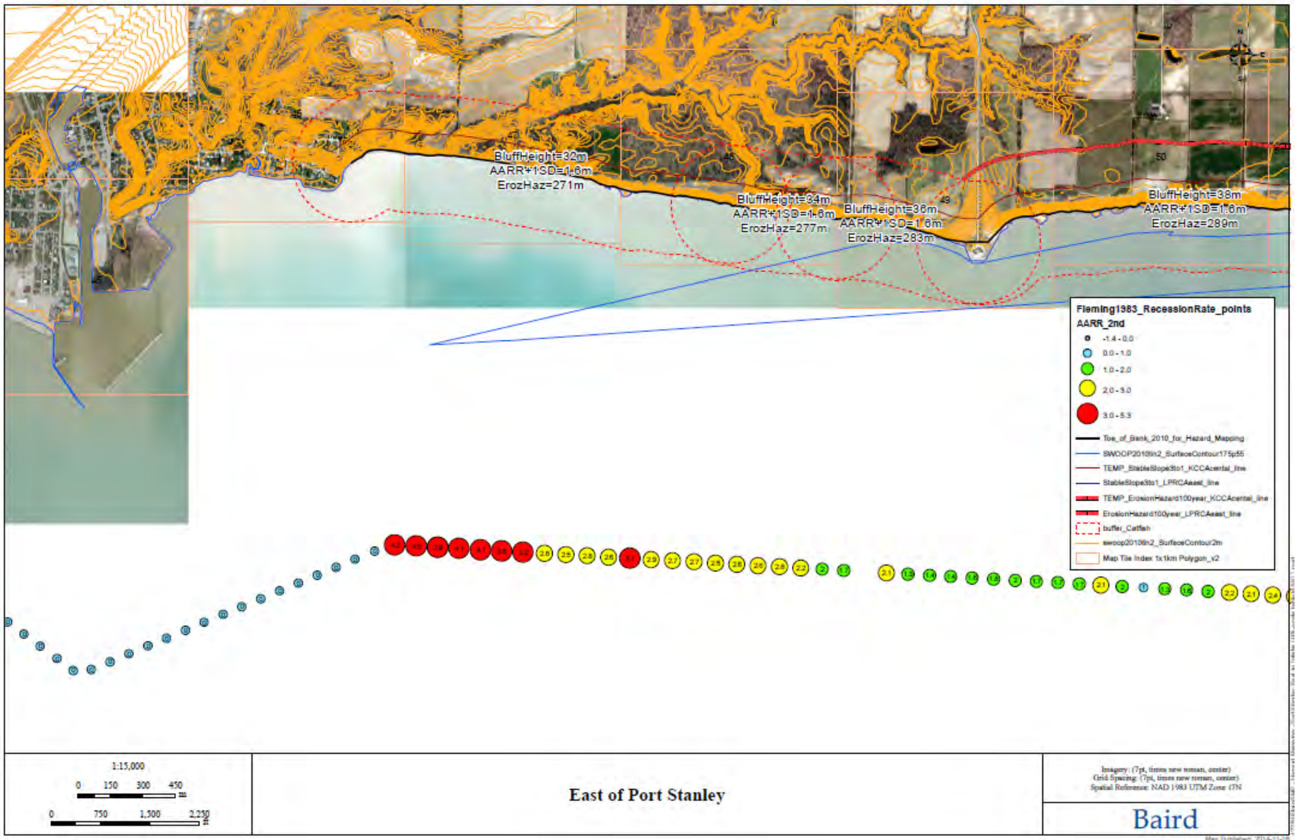


Figure 2.15 Sample Plot of the Fleming (1983) Baseline and Recession Rates

All of the Fleming (1983) transects between Port Stanley and Port Bruce from 1937 and 1968/75 are plotted in Figure 2.16 and as noted earlier, there is considerable spatial variability in the measured recession between these two port communities. The measured recession was converted to an annual recession rate for each transect in Figure 2.17 by dividing the erosion distance by the temporal period. The measured erosion rates ranged from a high of 4.5 m/yr to a low of 0.6 m/yr.

When measuring historical erosion rates across a regional area, such as Port Stanley to Port Bruce, individual transect measurements such as the 100 m Fleming (1983) data have historically been averaged together to produce one average annual recession rate (AARR) for the stretch of coastline. The logic behind the AARR was to smooth the data and remove the local variability. The AARR for the Fleming (1983) data, 1.9 m/yr, was added to Figure 2.17. Interestingly, very few of the historical recession rates actually correspond to the average due to the large amount of spatial variability in the rates. Since the historical AARR is used in setback planning as an estimate of the future erosion rate for a given area, the results in Figure 2.17 suggest it may not be a good predictor. In other words, if very few of the bluffs eroded at the AARR historically, there is no guarantee they will erode at a rate equal to or similar to the AARR in the future. Fortunately, the Technical Guide (MNRF, 2001a) recommends the AARR is the minimum rate for setback planning and therefore a different approach will be required for this SMP.

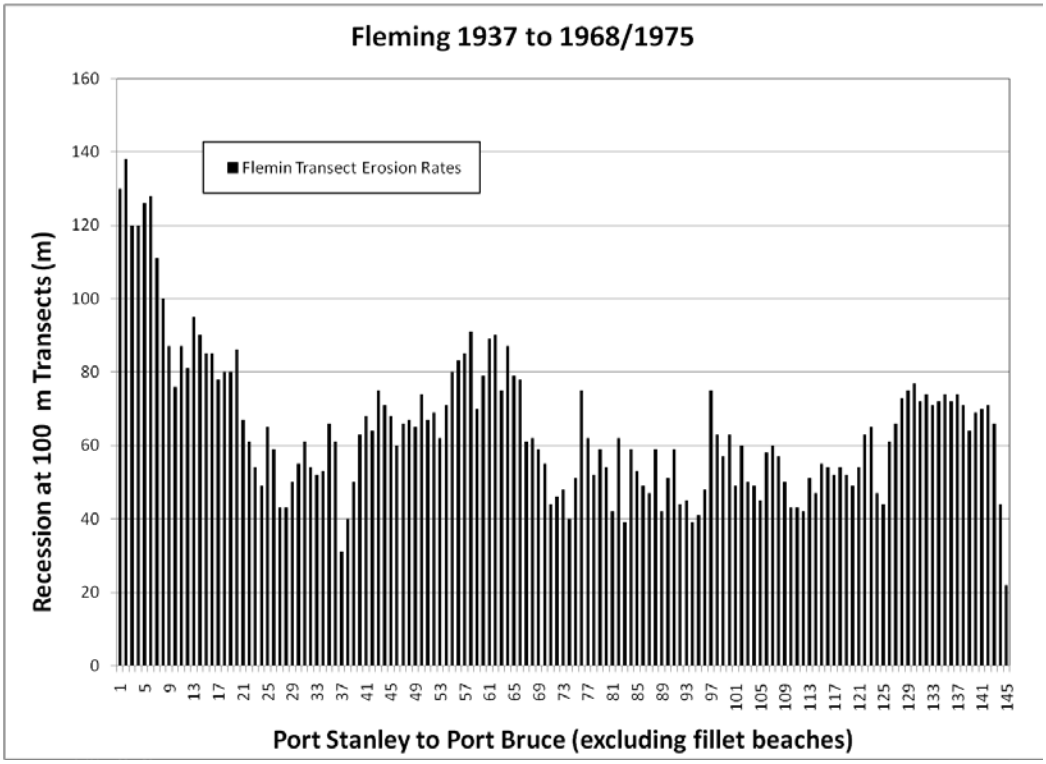


Figure 2.16 Recession Measurements at Individual Transects from Port Stanley to Port Bruce

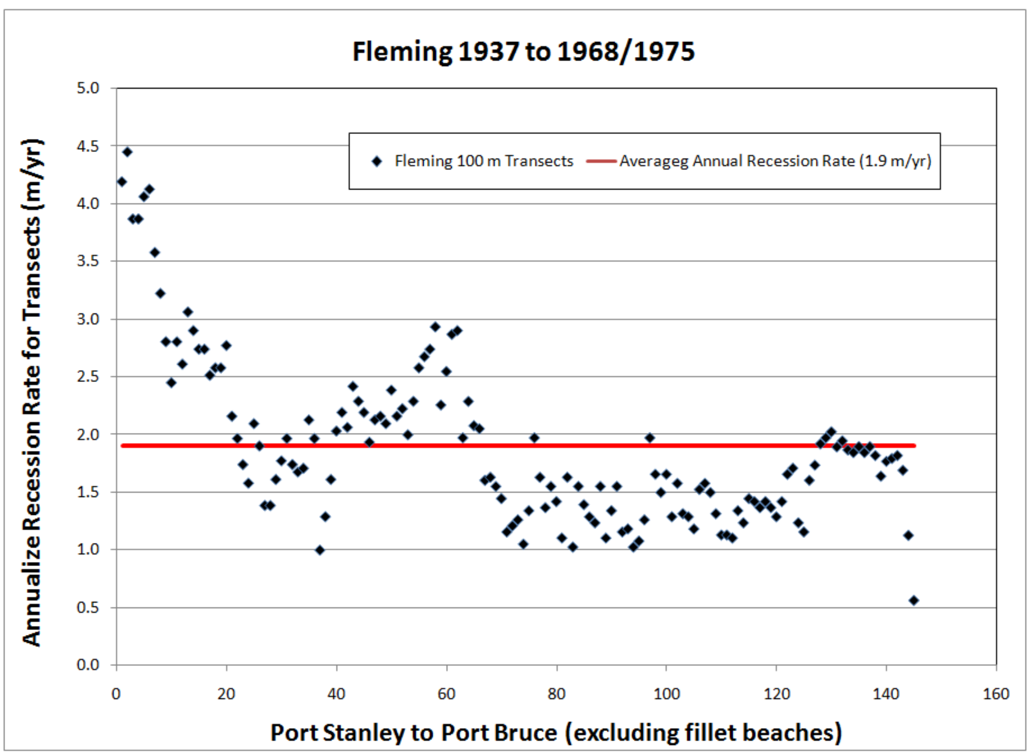


Figure 2.17 Annualized Recession Rate for Individual Transects and AARR for all Transects (m/yr)

The annualized recession rates for the individual Fleming (1983) transects from Port Stanley to Port Bruce were sorted from lowest to highest and plotted in Figure 2.18. Simple statistical parameters to characterize this population, including mean (or AARR), the AARR +/- one and two Standard Deviations (SD) were also plotted. As expected for a normal population distribution, 95% of the annualized recession rates fall within the limits of the AARR +/- two SD. Plots for the remaining sections of coastline in the SMP are provided in Appendix A and show similar trends, with very few of the individual transects actually featuring an erosion rate equal to or similar to the mean or AARR.

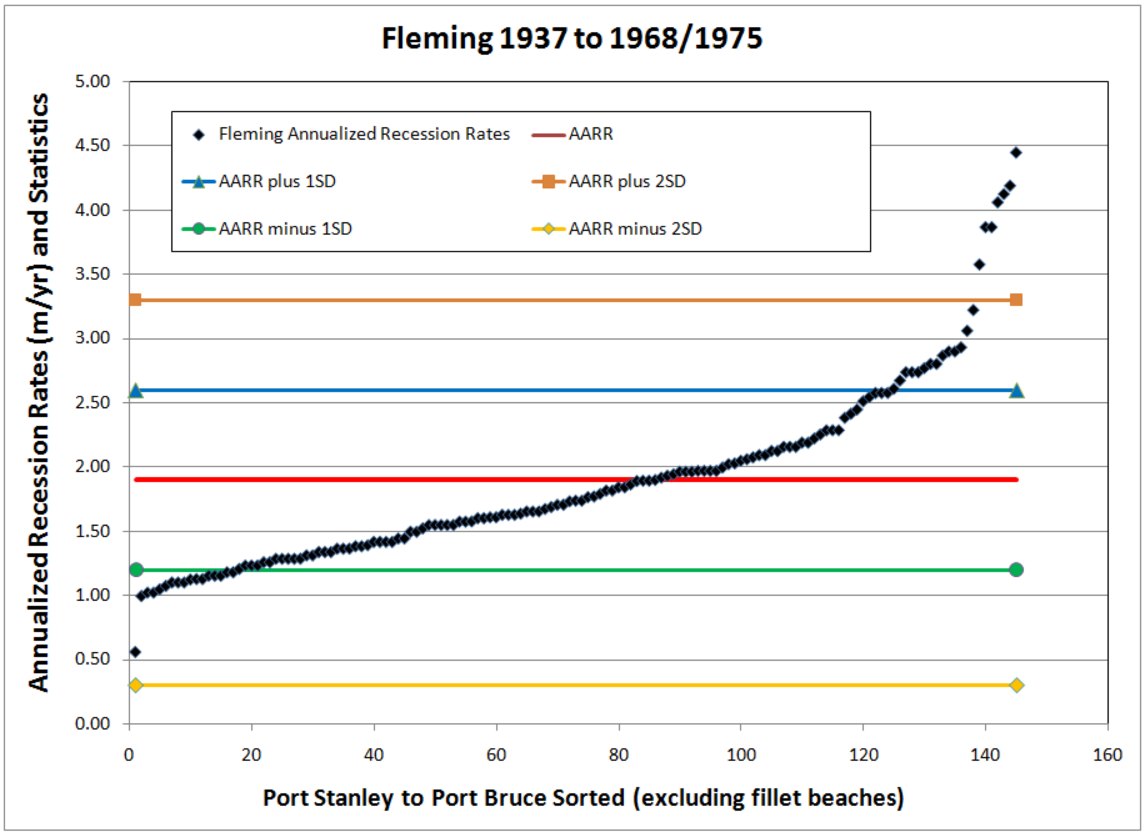


Figure 2.18 Annualized Recession Rates (m/yr) from Port Stanley to Port Bruce, plus Statistical Characterization of the Population

These findings have important implications for the selection of an appropriate long-term recession rate to generate the hazard mapping for this SMP, since the historical recession rates are being used to estimate the amount of future erosion. For example, if the AARR (or mean) for the stretch of coast between Port Stanley and Port Bruce was used to delineate the 100 year erosion setback, roughly half of the shoreline would erode at a rate less than the AARR (1.9 m/yr) and the remaining half would erode at a rate faster than the AARR. In other words, the erosion hazard setback would only be 50% successful at mitigating future erosion over the 100 year planning horizon for this particular stretch of coastline.

The limitations of mapping hazard setback lines with the AARR were first documented in Zuzek et al (2003). The recommended approach to address this limitation associated with using the AARR was adding one or two SD to the AARR. If one SD was added to the AARR for the stretch of coast between Port Stanley and Port Bruce, it would encompass 86% of the historical transect measurements. Translating this statistical analysis to erosion hazard setback planning, the AARR plus one SD would be 86% successful at locating future development landward of the eroding bluff over the 100 year planning horizon.

2.4.2 Baird Recession Calculations (1977/78 to 2010)

Historical aerial photographs were available for the majority of the study coastline from flights completed in 1977 and 1978. This imagery was acquired from the four CAs. In locations with sufficient ground control along the coast in both photo series (i.e., 1977/78 and 2010), such as local road networks, the historical imagery was geo-referenced to the 2010 county wide orthophotographs for Elgin County. A total of nine bluff areas were investigated covering 12.8 km of shoreline.

Once geo-referenced, the top of bank was digitized for the eroding bluffs in both the 1977/78 and 2010 imagery. Then, a custom software application, Baird ShoreTools (Baird, 2001) was used to generate shore perpendicular erosion transects between the historical and 2010 bluff crest position. The transects were spaced at 10 m increments. Locations with gullies that emerge at the coast were omitted, as were locations with heavy vegetation, as the bluff crest position could not be accurately located. Areas with existing shoreline protection were also omitted from the analysis, as the long-term erosion trend has been biased by the protection. The results are plotted for five of the nine areas in Figures 2.19 to 2.24, with statistics summarized below:

- Figure 2.19: A total of 173 erosion transects, featuring an AARR of 0.7 m/yr and an AASD of 0.3 m/yr.

- Figure 2.20: A total of 32 erosion transects, featuring an AARR of 1.6 m/yr and an AASD of 0.3 m/yr.

- Figure 2.21: The 1977 and 2010 imagery and bluff crest position northeast of Duttona Beach. A total of 183 transects, featuring an AARR = 0.48 m/yr, AASD = 0.22 m/yr.

- Figure 2.22: The Baird erosion transects are plotted in chronological order west to east (black diamonds) and in ascending order (grey diamonds). The spatial variability observed in Fleming (1983) and discussed in Section 2.4.1 was also observed in these Baird measurements. And similarly, the AARR +/- 2SD encompasses the majority of the results (i.e., greater than 95%).

- Figure 2.23: A total of 151 erosion transects, featuring an AARR of 1.6 m/yr and a SD of 0.3 m/yr.

- Figure 2.24: A total of 165 erosion transects, featuring an AARR of 1.7 m/yr and a SD of 0.3 m/yr.

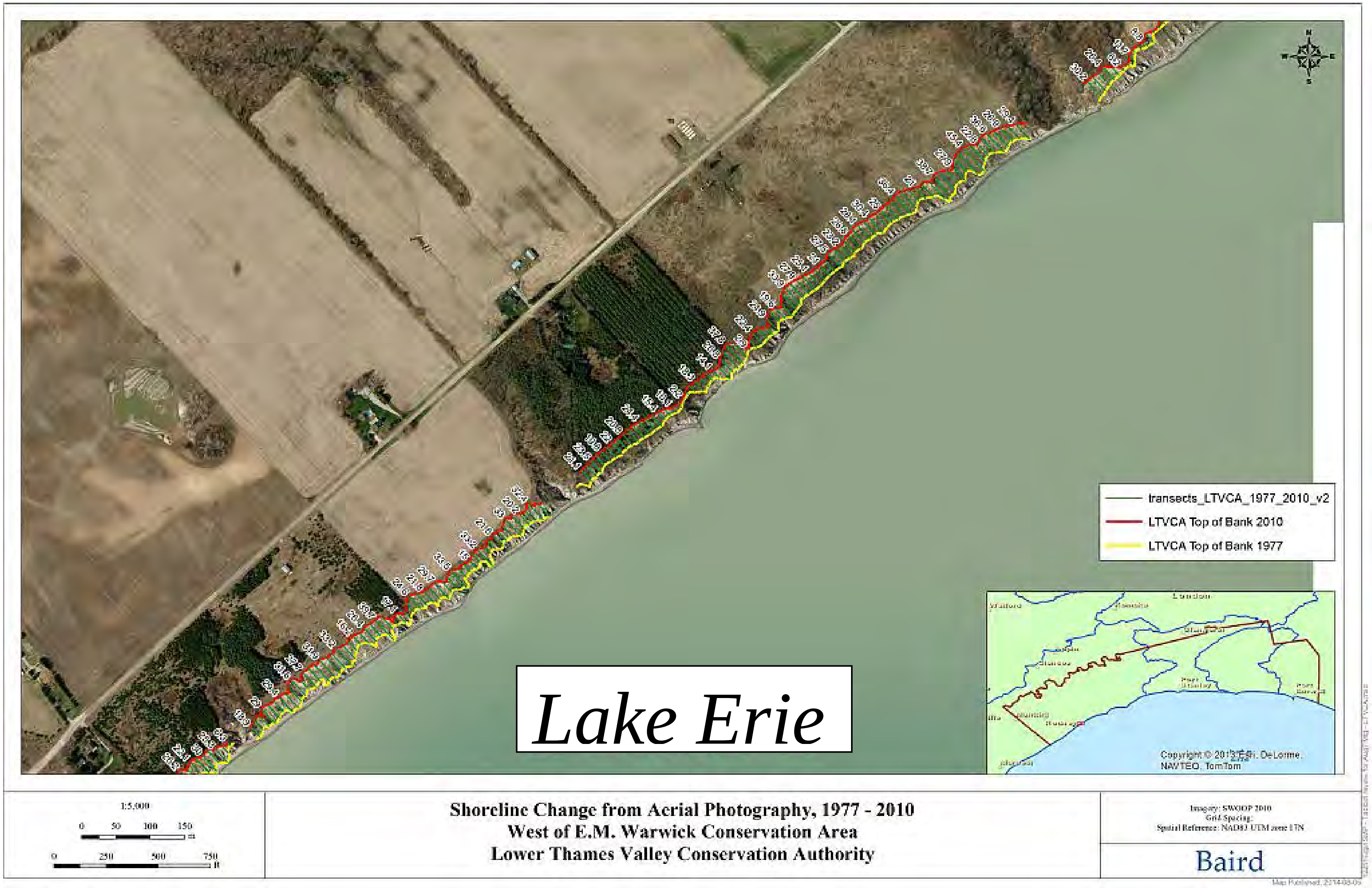


Figure 2.19 1977 to 2010 Erosion Measurements West of E.M. Warwich Conservation Area, LTVCA

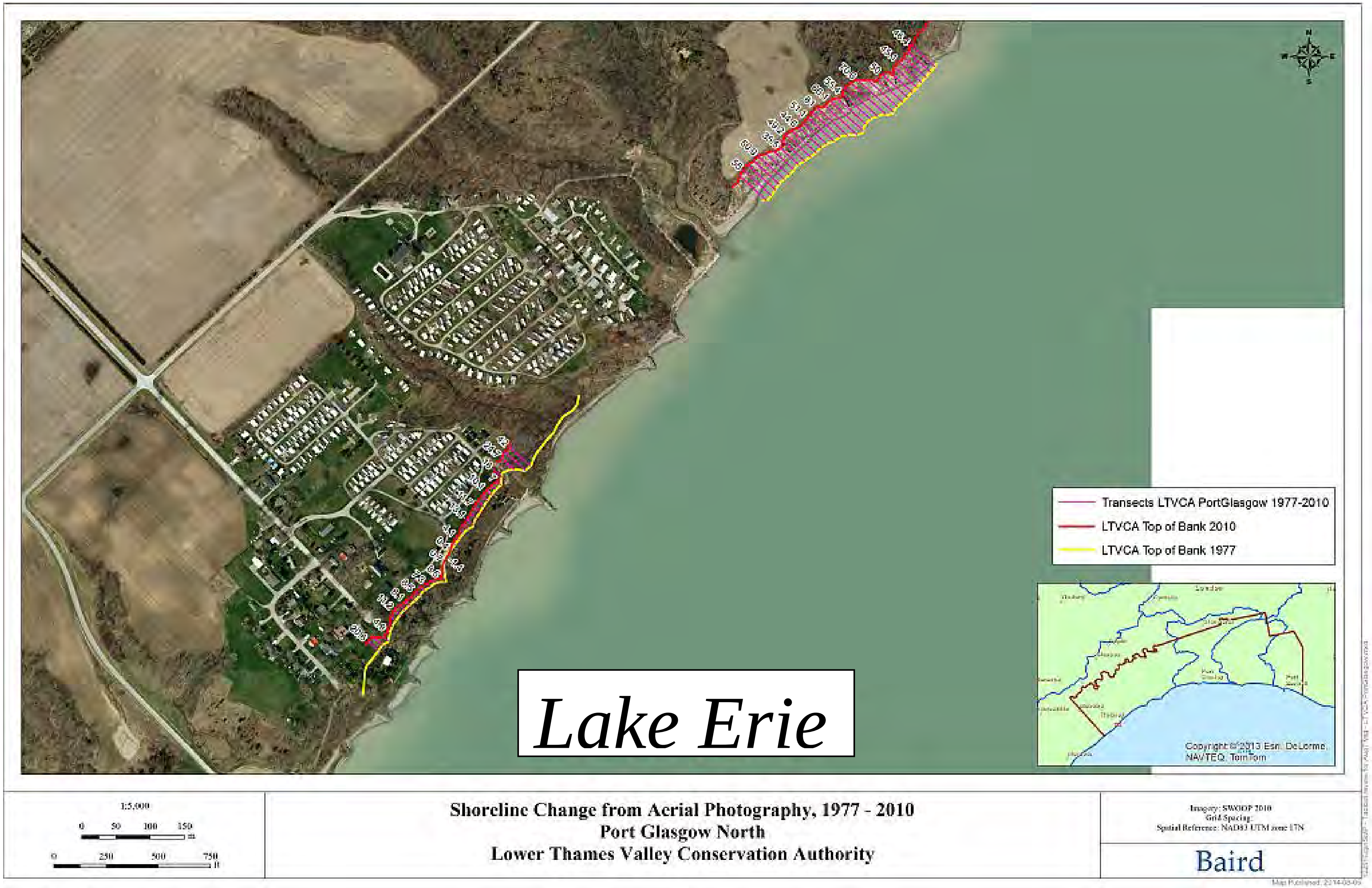


Figure 2.20 1977 to 2010 Erosion Measurements Northeast of Port Glasgow, LTVCA

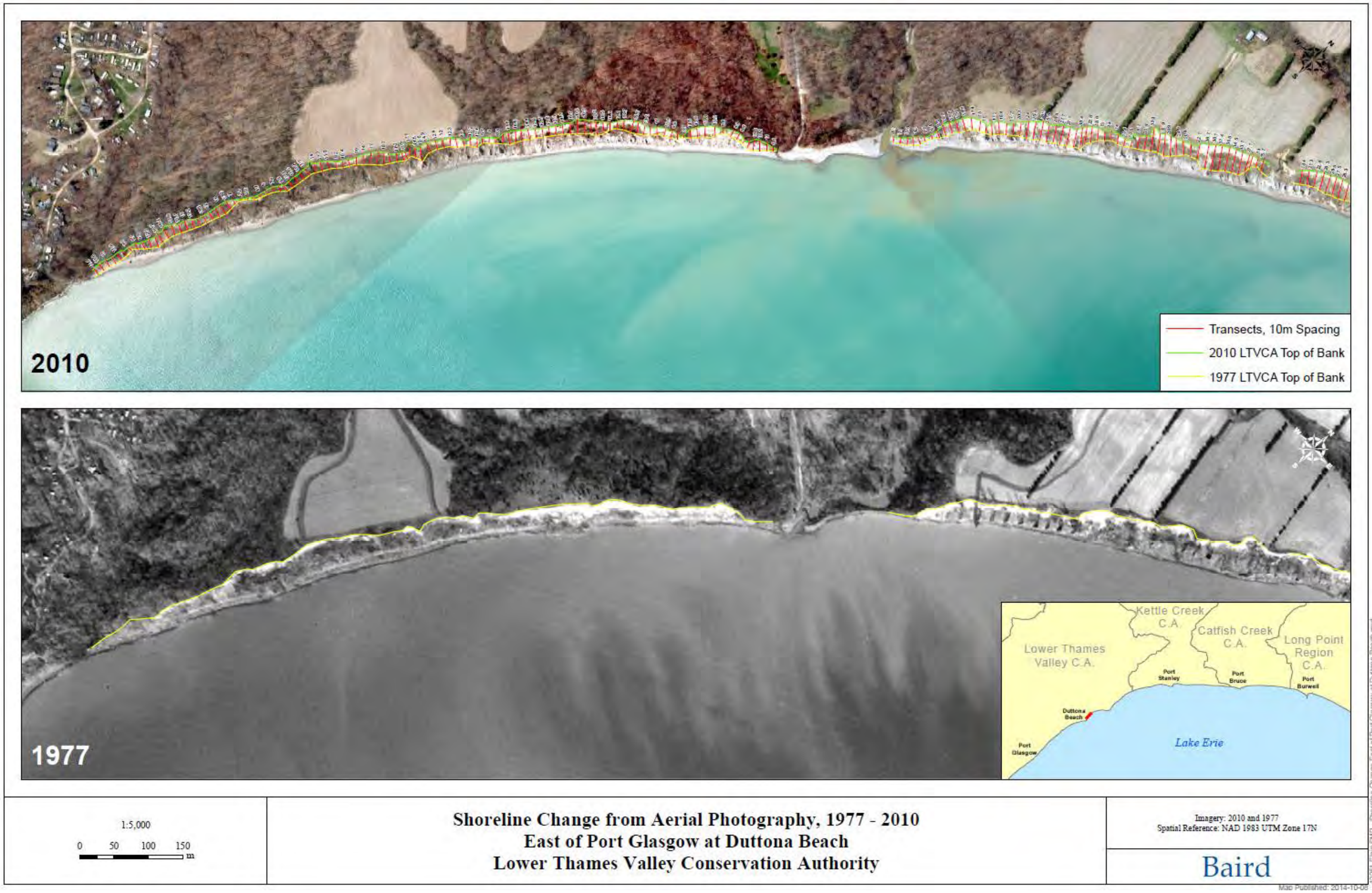


Figure 2.21 1977 to 2010 Erosion Measurements Northeast of Duttona Beach, LTVCA

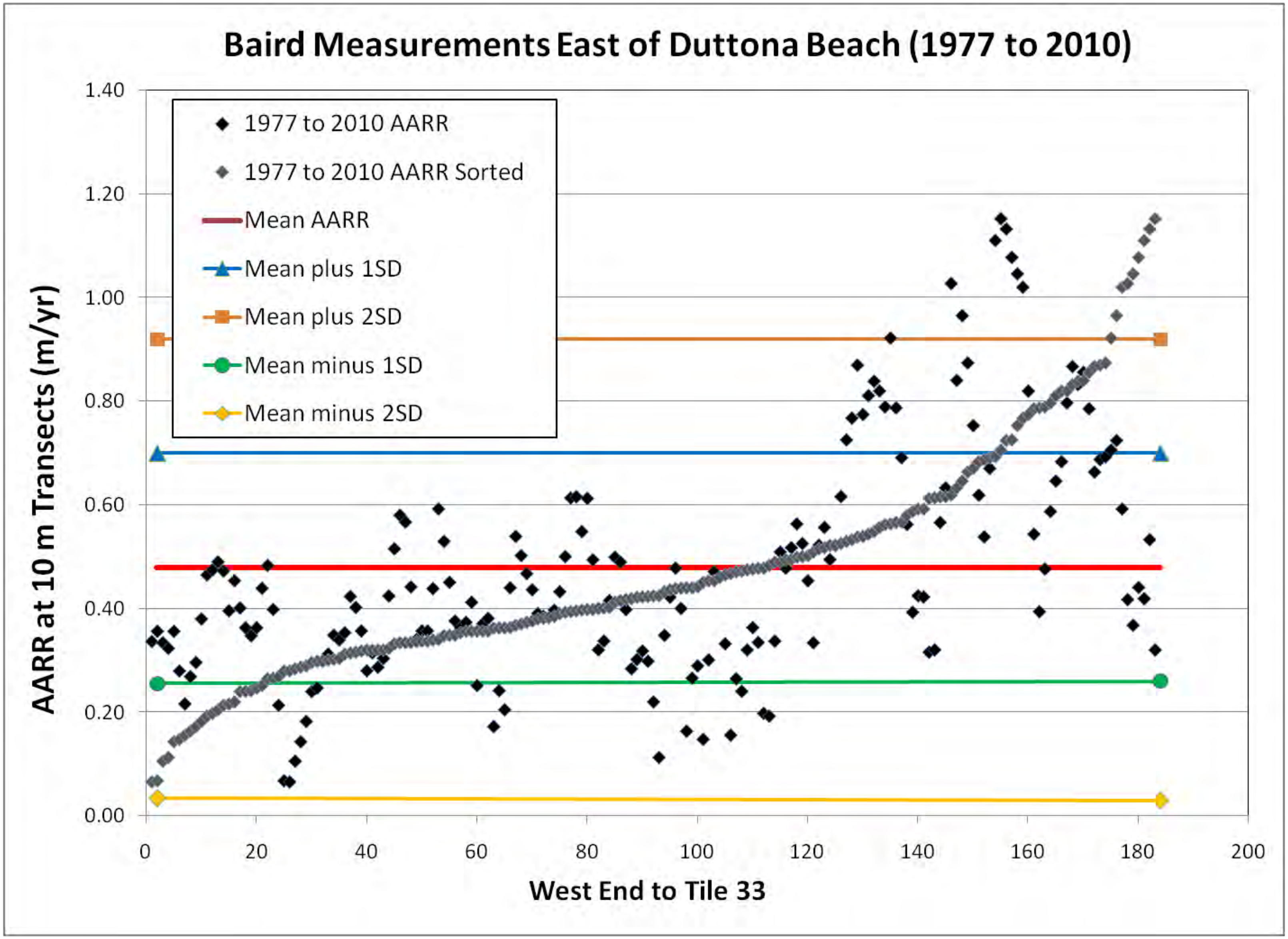


Figure 2.22 1977 to 2010 Baird Erosion Transects at Duttona Beach, Raw and Sorted

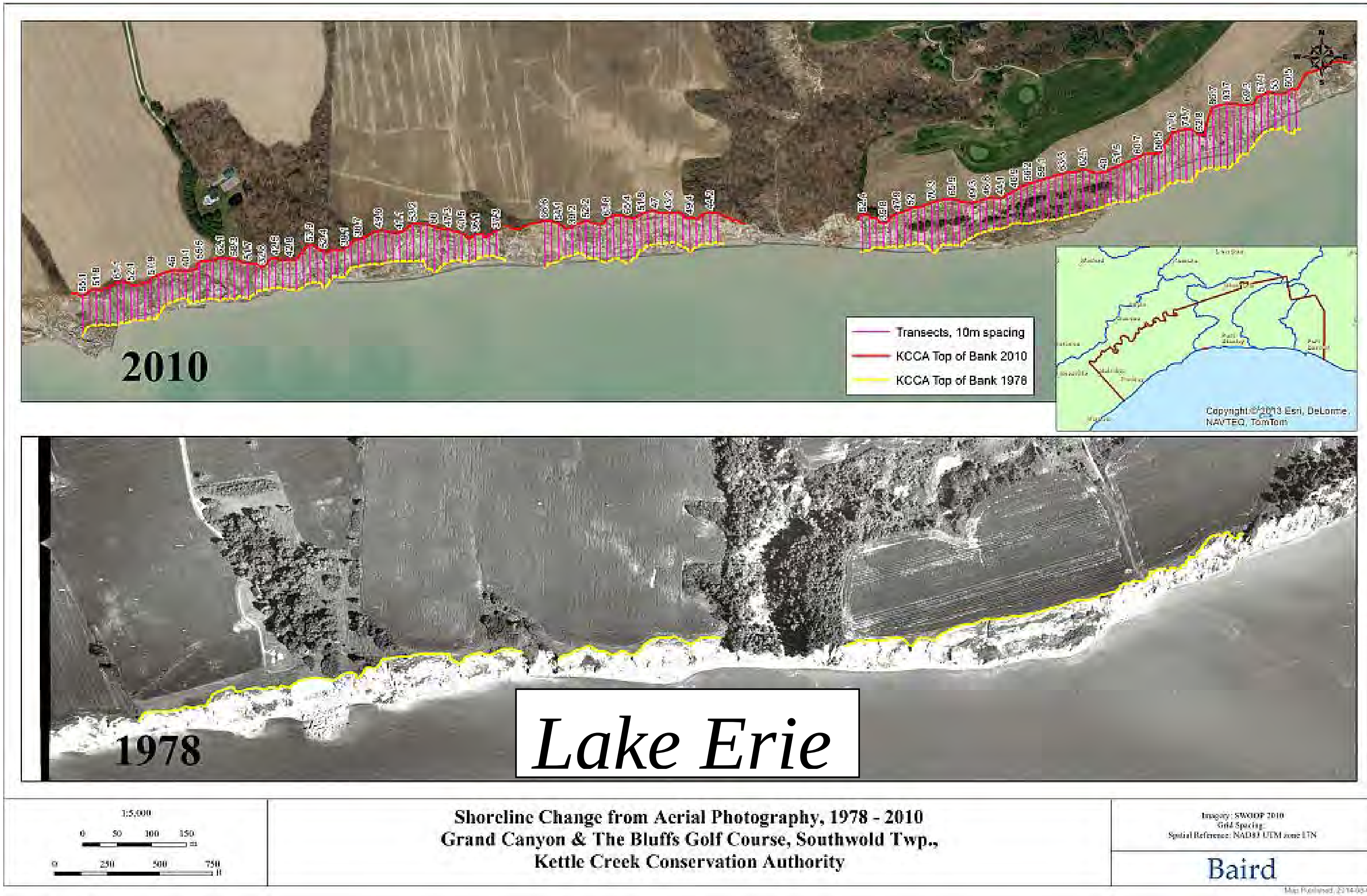


Figure 2.23 1978 to 2010 Erosion Measurements at Grand Canyon and the Bluffs Golf Course, KCCA

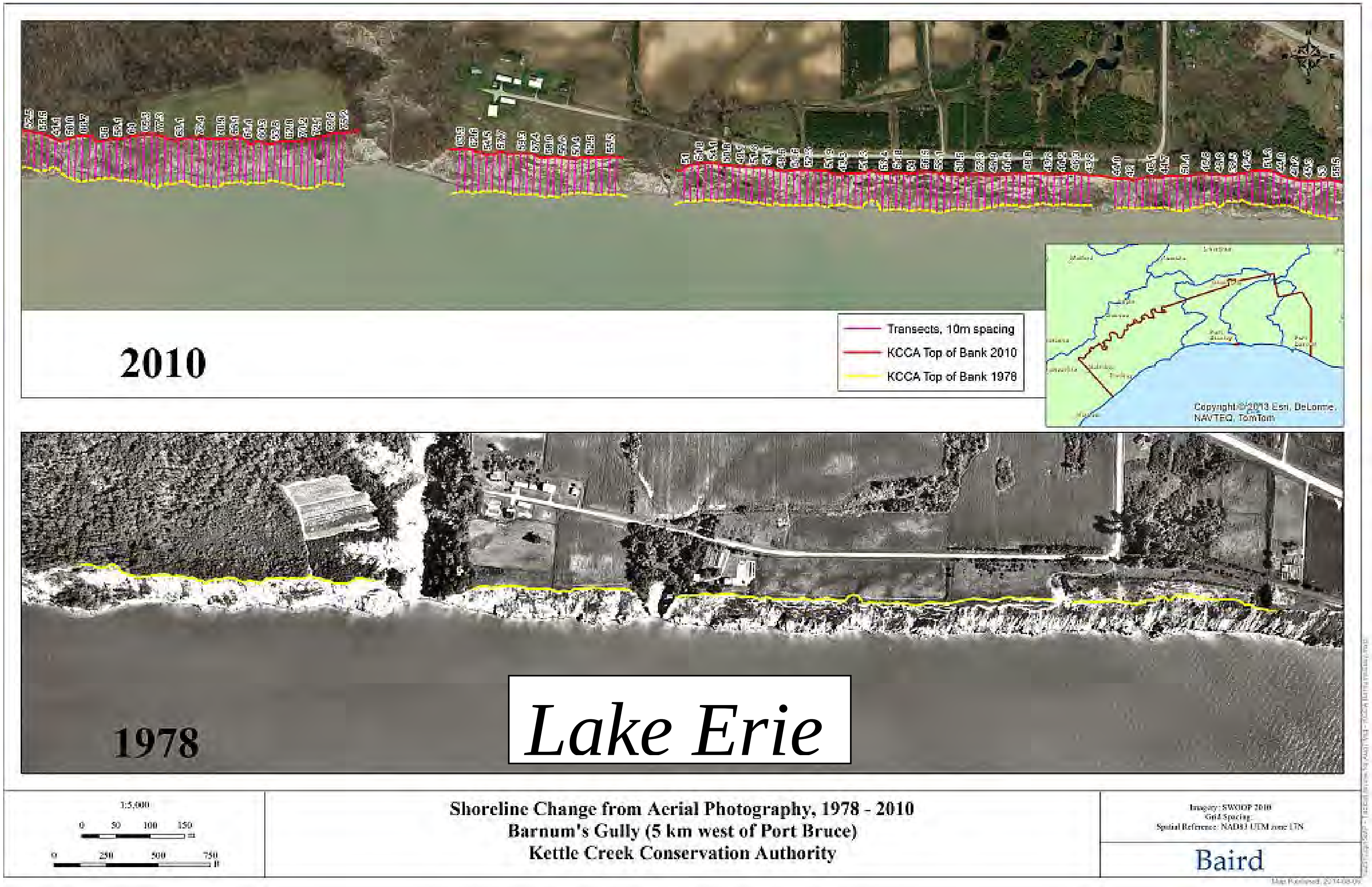


Figure 2.24 1978 to 2010 Erosion Measurements at Barnum`s Gully, KCCA

2.4.3 Adopted Recession Rates for Setback Planning

The Baird recession measurements at the nine locations for the period 1977/78 to 2010 were compared to the historical results published by Fleming (1983), which provide complete spatial coverage for Elgin County. The results are compared in Table 2.1. Unfortunately, it was not possible to register any historical aerials from Port Stanley to the Elgin Pumping Station due to lack of ground control in this agricultural area (i.e. no development features common to both photo series). In the remaining shoreline segments, the Baird recession rates showed good agreement with Fleming (1983). The fact that the rates compared well confirms the suitability of the Fleming (1983) data for defining the erosion hazards throughout Elgin County.

Table 2.1 Comparison of Fleming (1983) and Baird Recession Rate Data

Shoreline Limits	Tile Range		CA	Fleming 1936 to 1968/75			Baird 1977/78 to 2010				Comparison of Baird and Fleming Measurements
	From Tile	To Tile	Jurisdiction Limits	AARR (m/yr)	AASD (m/yr)	AARR+1SD (m/yr)	Length of Calcs.	AARR (m/yr)	AASD (m/yr)	AARR+1SD (m/yr)	
West End to Tile 32	1	32	LTVCA (1 to 32)	0.7	0.3	1.0	1.7 km	0.7	0.3	1.0	Baird Rate Similar
							0.3 km	1.6	0.3	1.9	Baird Rate Higher
							1.8 km	0.48	0.22	0.7	Baird Rate Lower
Tile 33 to Port Stanley	33	42	LTVCA (33 to 35), KCCA (35 to 42)	1.3	0.3	1.6	1.8 km	1.6	0.3	1.9	Baird Rate Higher
Port Stanley to Elgin Pumping Station	46	49	KCCA (46 to 49)	2.9	0.8	3.7	*Not possible to geo-reference historical arial photographs in this reach*				No Baird Measurements
Elgin Pumping Station to Port Bruce	49	61	KCCA (49 to 59), CCCA (59 to 61)	1.7	0.5	2.2	1.9 km	1.7	0.3	2.0	Baird Rate Similar
Port Bruce to Port	62	76	CCCA (62 to 74), LPRCA (74 to 76)	1.8	0.5	2.3	1.0 km	1.2	0.2	1.4	Baird Rate Lower
							0.7 km	1.5	0.2	1.7	Baird Rate Similar
							1.8 km	1.5	0.3	1.8	Baird Rate Similar
Port Burwell to East End	80	88	LPRCA (80 to 88)	4.1	0.7	4.8	1.8 km	3.1	0.7	3.8	Baird Rate Similar in Area of Overlap

Based on the assessment of spatial variability in erosion rates and the limitations associated with developing erosion setbacks with only the mean or AARR, this SMP will utilize the AARR plus one AASD to define the 100 year erosion hazard setback.

2.4.4 Comparison of Elgin County Recession Rates to Lakes Ontario and Michigan

The AARR in Table 2.1 range from 0.7 to 4.1 m/yr. To put these rates in context, similar information is presented for Lake Ontario and Michigan. Historical information on bluff recession was available from two lakewide studies, namely the IJC Lake Ontario – St. Lawrence River Regulation Study (Baird, 2006) and the Lake Michigan Potential Damages Study (Baird, 2001) a variety of published sources for the entire perimeter of both lakes and then averaged for continuous 1 km shoreline reaches. Refer to Figure 2.25 for a map of the continuous 1 km shoreline reaches on the southwest shoreline of Lake Ontario.

The AARR per kilometre of shoreline on Lake Ontario are presented in Figure 2.26, sorted from lowest to highest. The negative AARR correspond to regions of the lake with a positive recession rate (i.e. a depositional trend). The average of all the AARR for the entire lake is 0.26 m/yr. Only 4% of the AARR on Lake Ontario are actually higher than 1.0 m/yr, with the highest rate on the lake equal to 2.15 m/yr.

Figure 2.25 Southwest Coastline of Lake Ontario and 1 km Reaches (red circles)

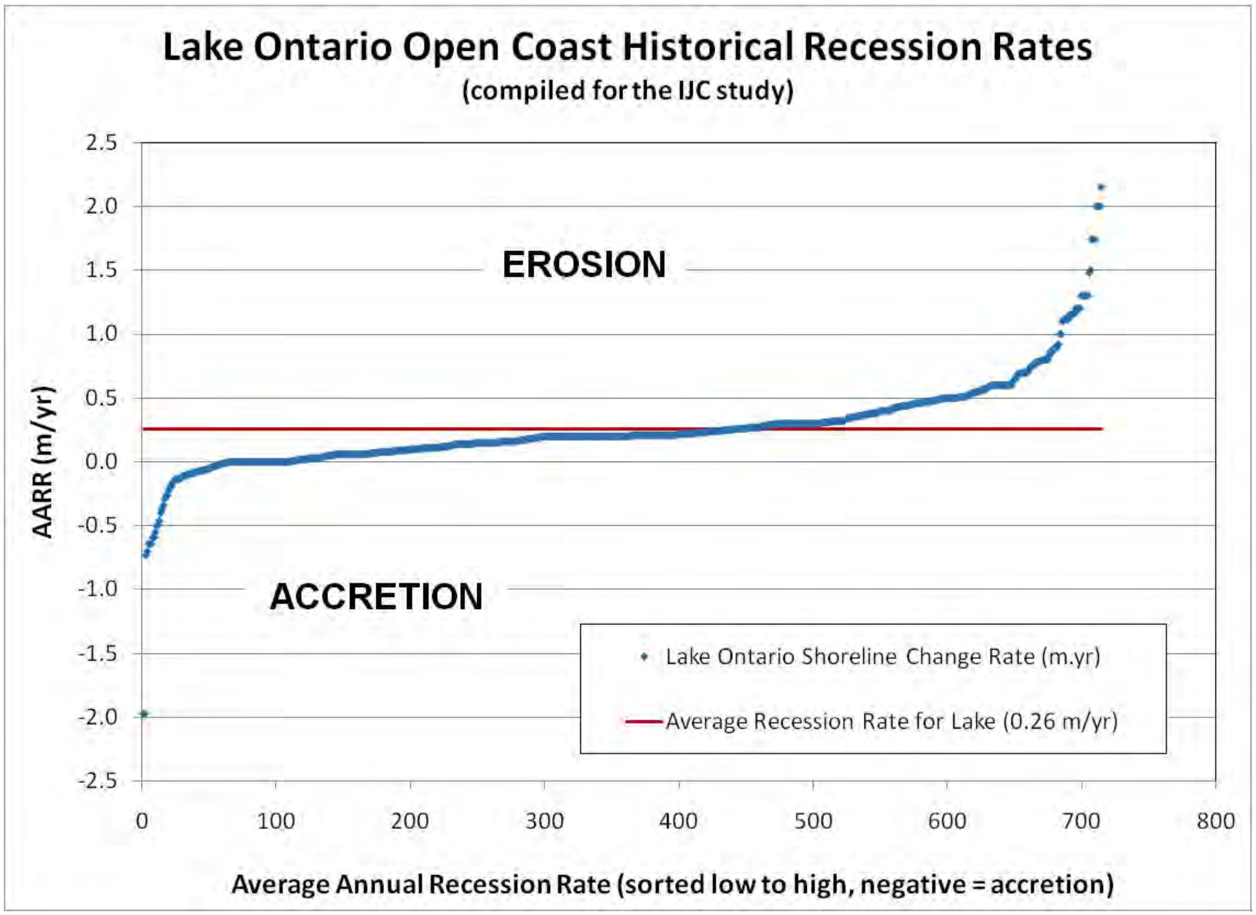


Figure 2.26 Lake Ontario AARR per 1 km Reach

The Lake Michigan results are summarized in Figure 2.27. The average AARR for the lake is slightly higher than Lake Ontario at 0.3 m/yr. Only 5% of the AARR at the individual reaches are greater than 1.0 m/yr.

Based on the lakewide recession measurements from Lake Ontario and Erie, it is clear the recession rates in Elgin County greatly exceed those measured in these other two lakes.

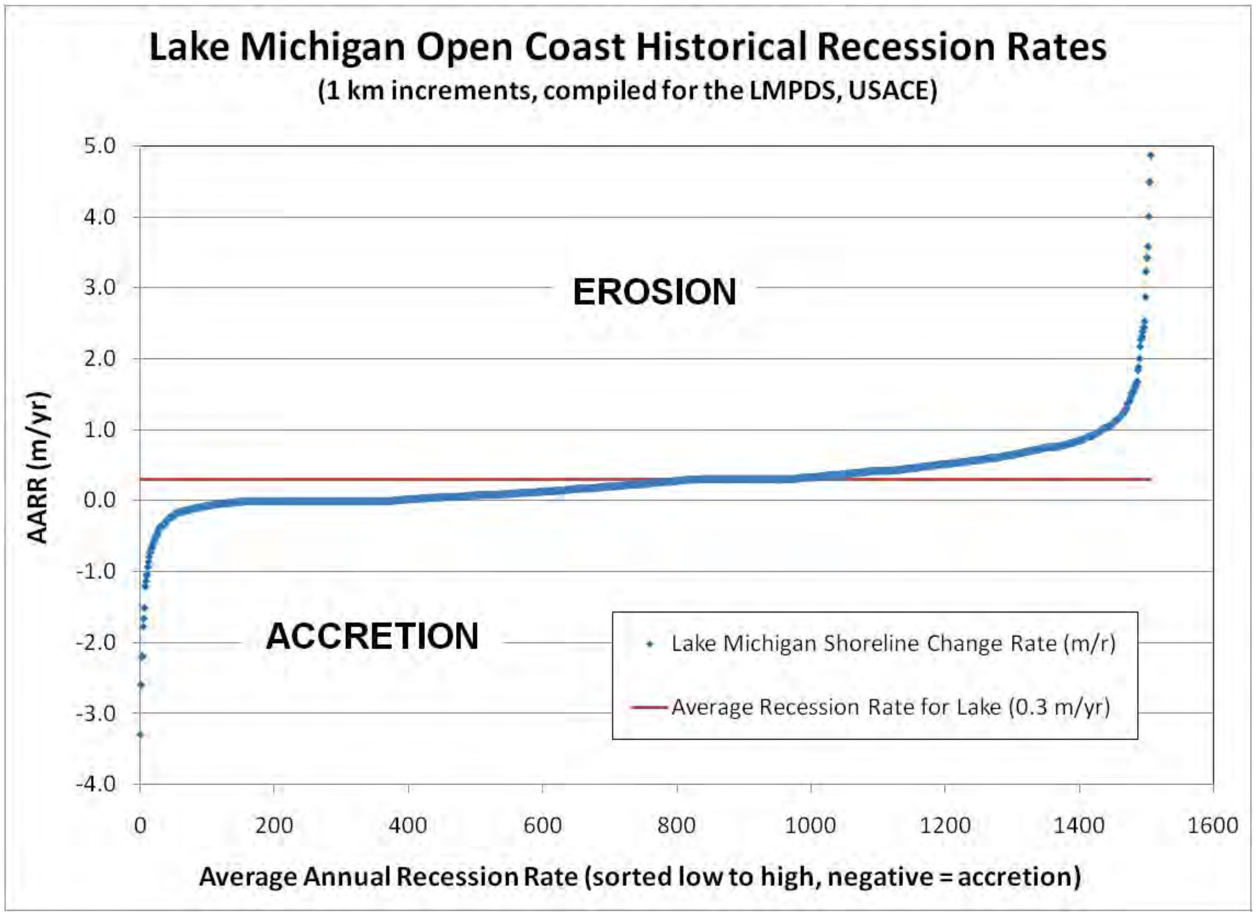


Figure 2.27 Lake Michigan AARR per 1 km Reach

2.5 Evaluation of Lake Levels

Recorded water levels on Lake Erie extend back to 1865 based on data for US gauges collected by NOAA. Figure 2.28 provides a plot of the monthly mean Lake Erie water level from 1865 to the end of 2013. Since the late 1990s, water levels have been in a long average trend, following three decades of above average water levels in the 1970s, 1980s, and 1990s.

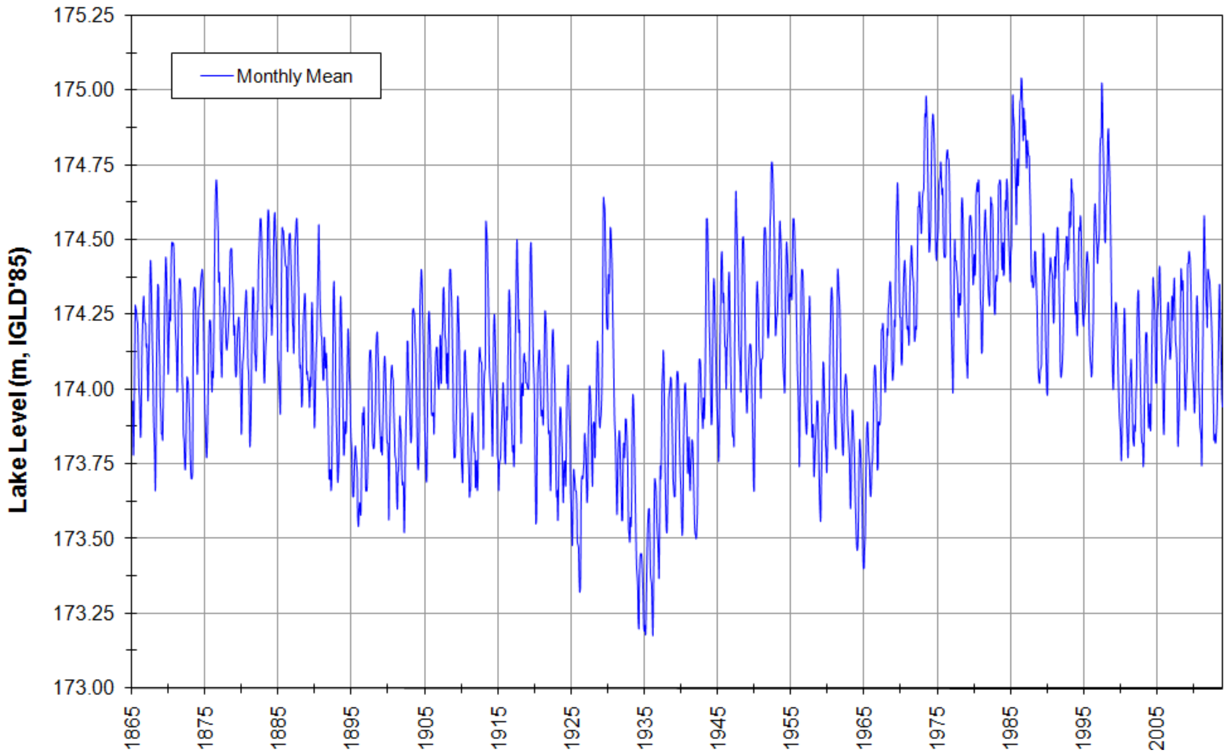


Figure 2.28 Lake Erie Monthly Mean Water Levels 1865 to Present

Water levels on Lake Erie have been highly variable since record keeping began and this trend is expected to continue into the future. While the recent Lake Erie trend has been average water levels, the delineation of flooding hazards for this SMP must consider the long-term water level record (i.e. highs and lows) to establish a probabilistic estimate of future flood risk.

Portions of the Elgin County coastline are susceptible to lake flooding, especially in the low lying beach areas at the four port communities. The flood hazard limit is defined as the peak instantaneous lake level (mean lake level plus storm surge) having a probability of occurrence of 1% in any given year, plus a 15 m horizontal setback. The peak instantaneous lake level is also known as the 100 year flood level. The existing SMP developed approximately 25 years ago relied on an MNRF publication (1989) to establish the 100 year flood level. Given that an additional 25 years of measured lake level data is now available, it is prudent to re-evaluate historical record with the additional measured lake level data. The methodology followed to evaluate extreme lake levels at the Port Stanley gauge and the remainder of the study area is described in the following section.

2.5.1 Lake Level Extremes at the Port Stanley Water Level Gauge

Hourly water level records have been recorded at the Port Stanley gauge since November 1961. Therefore, the temporal duration of the storm surge and extreme value analysis completed for this SMP update is focused on January 1st 1962 to December 31st 2013 (52 years). The historical lake levels were statistically analyzed to establish plausible future extreme conditions with return period intervals. Since the physical conditions of the Great Lakes and connecting channels are constantly changing due to engineering projects, erosion processes, sedimentation, and isostatic rebound, the conveyance of water through the system changes over time. To account for these changes in the physical properties of the lakes, historical lake levels are routinely corrected or adjusted so they are representative of the present physical conditions in the lakes. Then, the historical water levels recorded at the gauges is representative of the water level conditions that would occur today under the identical climatic conditions. This analysis is called the Basis of Comparison (BOC) and generates a correction factor to adjust the long term static lake levels (e.g. monthly mean lake levels).

Based on past correspondence with the Detroit District Army Corps of Engineers (pers. comm. Nanette Noorbakhsh Sept. 6, 2013) static lake levels from 1962 to 1974 during months May to November were adjusted by the values summarized in Table 2.2. These values represent the BOC adjustments. No changes were made to the historical data from 1975 to 2013.

Table 2.2 Lake Erie BOC Adjustment Values

Year	BOC Adjustment Value (m)
1962	0.01
1963	0.04
1964	0.06
1965	-0.04
1966	-0.06
1967	-0.05
1968	-0.04
1969	-0.07
1970	-0.05
1971	-0.04
1972	-0.05
1973	-0.04
1974	-0.03

Historical storm surge events were extracted from the hourly water level data at the Lake Erie water level gauge in Port Stanley. Specifically, the average static level was subtracted from the individual hourly records, which are influenced by wind and waves. The hourly lake levels at Port Stanley from 1962 to 2013 are plotted in the top panel of Figure 2.29. A moving average of the hourly data was generated with a Gaussian smoothing algorithm, which was set at 30 days to remove the effects of storm surges on the static lake level. The 'smoothed' long-term static lake level is plotted as the black line in the top panel of Figure 2.29. The difference between these two hourly records is the estimated storm surge, plotted as the red line in the bottom panel.

A peak over threshold (POT) analysis was performed on the storm surge data to determine extreme events in the dataset. The POT analysis relies on the following user defined parameters to identify unique extreme events exceeding a specific threshold (values used in this analysis are in parentheses).

- *Lamda* – number of selected events per year (10).
- *Threshold* – based on z-score, number of standard deviations above the mean value (3).
- *Inter-event time lag* – maximum time that a storm can temporarily drop below the threshold to still be considered a single unique storm (24 hours).
- *Minimum duration* – final check to screen data of single hour spikes (2 hours).

The top 52 storm surge events from the POT analysis were plotted on the probability of exceedance (POE) curve for all of the hourly surge data. This step ensures that the top storm surges are selected from the 'tail' of the curve; where values are most extreme (large surge values) and least likely to occur (low frequency). The POE curve is shown in Figure 2.30.

Each storm surge was visually inspected to ensure it did not have two peaks occurring within the inter event time. It also provided a check to make sure the blue dots in between the 1st and 52nd red dots are either hourly records from single hour events or a part of a higher ranked surge event. The largest storm surge on record (January 1st 1978) is plotted in Figure 2.31.

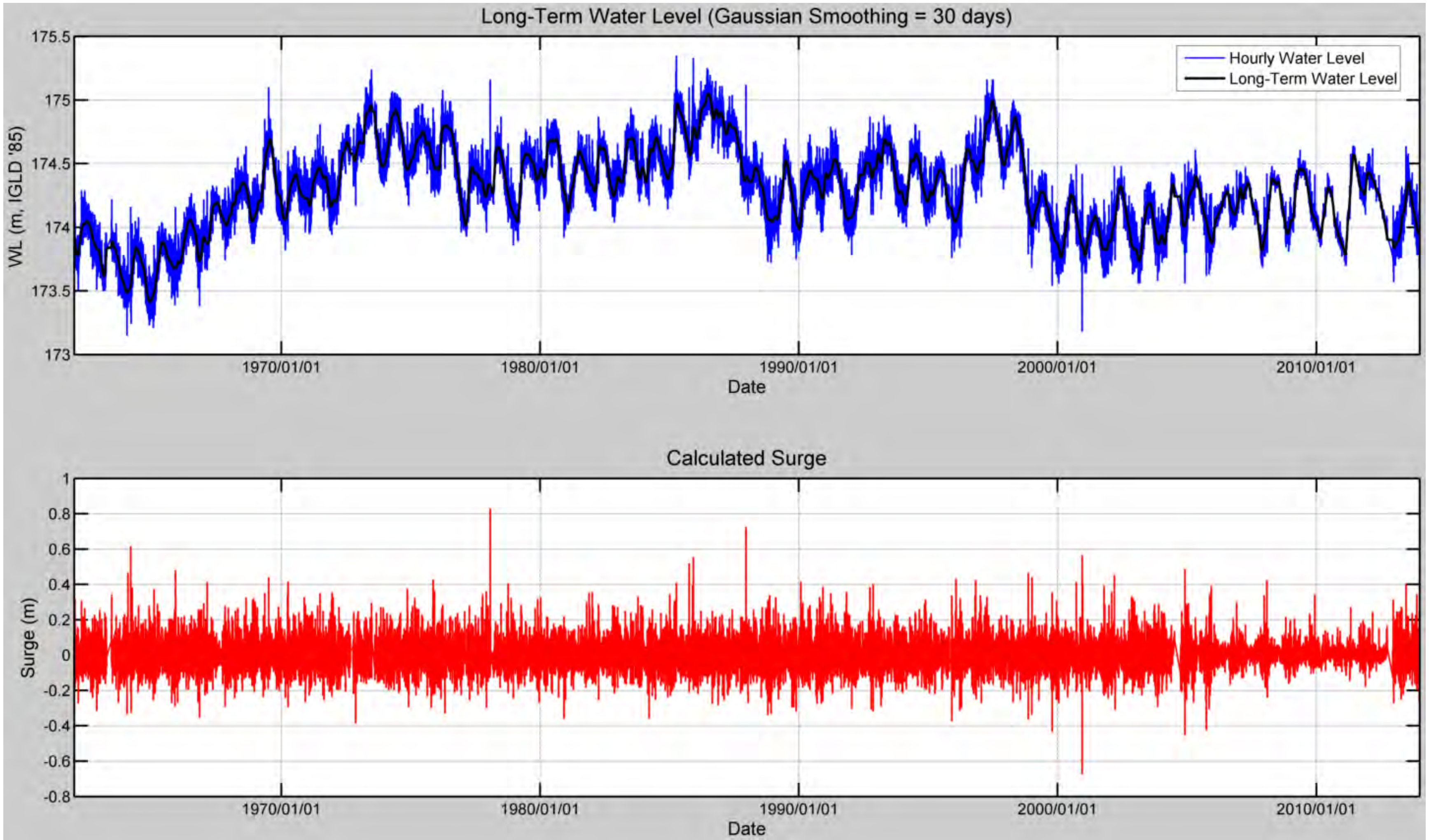


Figure 2.29 Hourly Water Levels and 30 Day Gaussian Average (top) and Calculated Hourly Storm Surge at the Port Stanley Gauge (bottom)

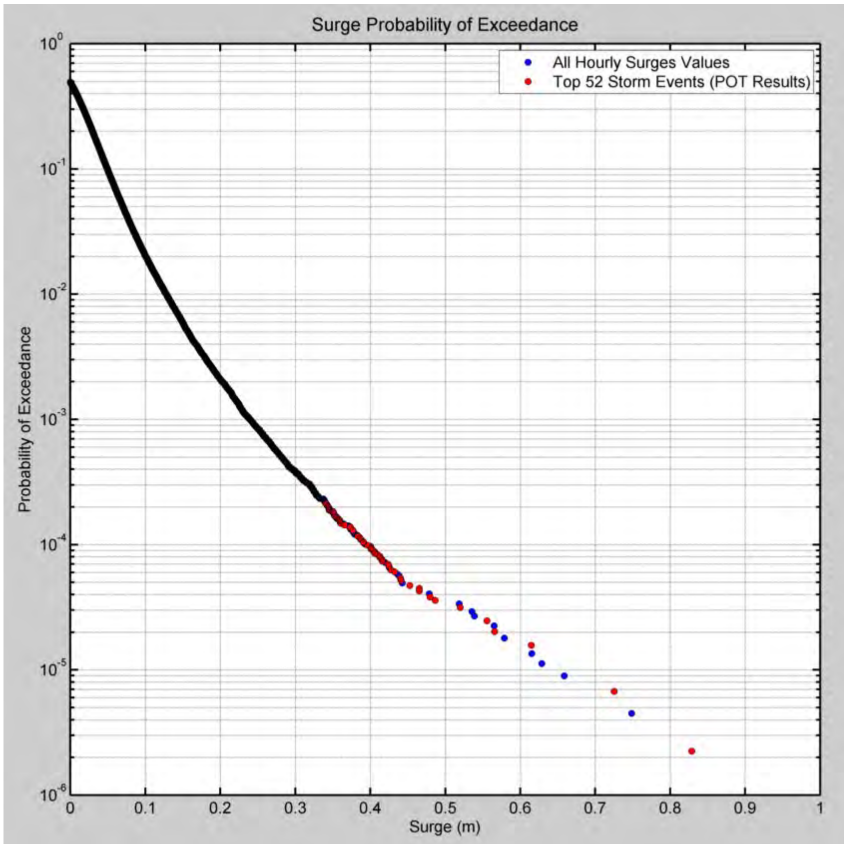


Figure 2.30 Probability of Exceedance (POE) Curve for the Port Stanley Gauge

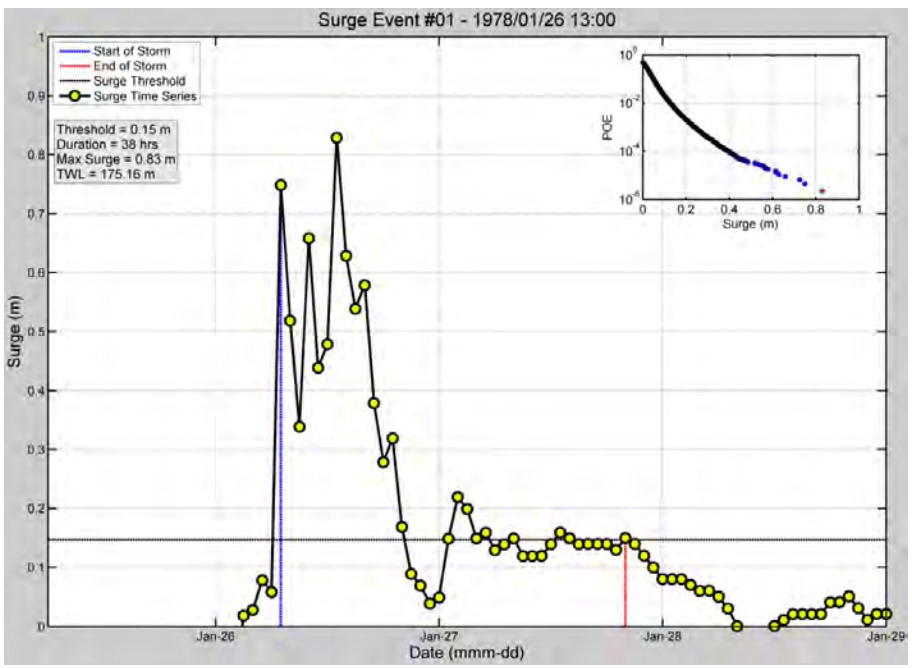


Figure 2.31 Largest Surge Event Recorded at the Port Stanley Gauge

2.5.2 Joint Probability Analysis

The total water level at the site is a combination of the static lake level and surge. These two variables are independent from one another, meaning that a surge event can occur at any water level because it is a function of wind conditions. In order to determine the probability of these two independent variables occurring at the same time a joint probability analysis (JPA) is required. HYSTAT, developed by the Ontario Ministry of Natural Resources in 1982, was used to conduct the joint probability analysis. Refer to Appendix B for a full technical description of HYDSTAT.

The two independent variables used in the HYDSTAT JPA were defined as follows:

- The annual maximum static water level for 52 years (from 1962 to 2013), estimated from the 30 day Gaussian smoothing routine discussed previously. Past similar analysis has been conducted using the annual maximum monthly average; using the annual maximum from the Gaussian smoothing routine removes bias created by the calendar months and returns the worst case static water level during a given year.

- The top 52 surge events from the POT analysis.

The HYDSTAT results, based on the distribution that fit the data with the lowest error (1.37E-03), Pearson III, are provided in Table 2.3.

Table 2.3 Joint Probability Analysis Results at Port Stanley Gauge

Return Period (Years)	Static Water Level (m IGLD ‘85)	Surge (m)	Total Water Level based on JPA (m, IGLD ‘85)
2	174.50	0.38	174.91
5	174.73	0.46	175.15
10	174.84	0.53	175.27
25	174.96	0.63	175.40
50	175.04	0.71	175.48
100	175.10	0.80	175.55
200	175.16	0.89	175.62

The estimated total combined still water level and surge based on the JPA for a 100 year return period is estimated to be 175.55 m IGLD’85. The Ontario Ministry of Natural Resources and Forestry (MNRF) estimated extreme water levels along the Canadian shores of the Great Lakes in 1989 based on the Canadian gauged data up to 1988. At the Port Stanley gauge MNRF estimates the 100 year return period total water level to be 175.5 m IGLD ’85 (MNRF, 1989).

2.5.3 Spatial Variability of the 100 Year Flood Level

Storm surge varies spatially on Lake Erie, with the highest elevations at the eastern and western extremes of the lake. The MNRF (1989) report on Great Lakes flood levels provides spatially varying 100 year water levels at Port Glasgow, Port Stanley, Port Bruce and Port Burwell based on the varying storm surge heights. These elevations are presently in use by the CAs for flood hazard regulation and are summarized in Table 2.4. For reference, the difference between the IGLD'85 and CGVD'28 is 0.03 m at Port Stanley. Therefore, the IGLD'85 datum is 0.03 m higher.

Table 2.4 Existing 100 Year Flood Level by CA

Location	100 Year Flood Level (m, CGVD'28)
Port Glasgow, LTVCA	175.4 m
Port Stanley, KCCA	175.5 m
Port Bruce, CCCA	175.6 m
Port Burwell, LPRCA	175.7 m

The Port Stanley elevation, 175.5 m CGVD28 (or 175.53 m IGLD'85) is very close to the updated value calculated for this study with 26 additional years of recorded water level data (175.55 m IGLD'85).

As part of FEMA's (Federal Emergency Management Agency) efforts to update their Great Lakes coastal floodplain maps, detailed ADCIRC storm surge models were developed for Lake Erie and Lake Ontario (Baird, 2012). Baird completed the storm surge model calibration and quality assurance checks for both lakewide models. Following the extensive Lake Erie ADCIRC model calibration against the measured gauge data, 150 of the largest historical storms were simulated to estimate time varying storm surge elevations around the perimeter of the lake. Two of these extreme events were selected to evaluate the spatial variability of the storm surge along the Elgin County shoreline and the range of values presented in Table 2.4.

The top panel in Figure 2.31 presents the lakewide bathymetry used in the model, along with the limits of Elgin County and the location of the Port Stanley gauge (red circle along shore within Elgin County). Lake Erie is the shallowest of the five Great Lakes, with the majority of the western basin less than 10 m deep and the deepest point off the tip of Long Point only 64 m. With the long-axis generally orientated east to west in alignment with strong storms from the west, it features ideal conditions for the generation of storm surges. During the peak of the December 15, 1987 event, the storm surge reached 1.6 m in the eastern end of the lake (at Port Colbourne/Buffalo), while conversely the western end of the lake featured a setdown (drop on lake elevation) of 2.0 m.

In the bottom panel of Figure 2.31 the maximum water level surface across the entire lake is plotted, as estimated by the computer model. The maximum storm surge across Elgin County ranged from 1.0 to 1.6 m, for a difference of 0.6 m. The elevations at Port Glasgow and Port Burwell were 1.1 m and 1.55 m respectively, for a difference of 0.45 m. The trend of increasing storm surge from Port Glasgow to Port Burwell in Figure 2.31 is consistent with the MNRF 100 year flood levels in Table 2.4.

The maximum storm surge conditions for the April 6, 1979 storm are presented in the bottom panel of Figure 2.32. The maximum surge increases from 0.6 to 1.2 m moving in a west to east direction across Elgin County. The increasing surge height towards the east is consistent with the published 100 year storm surge elevations from MNRF (1989) and the elevations presented in Table 2.4.

In summary, the updated 100 year flood level for the water level gauge in Port Stanley was the same as the historical value published by MNRF (1989). In addition, the trend of an increasing storm surge elevation from west to east was also confirmed with the detailed ADCIRC storm surge model simulations. Therefore, the present water levels used to map the flood hazards in the four CAs, as presented in Table 2.4, will be adopted for this update of the SMP.

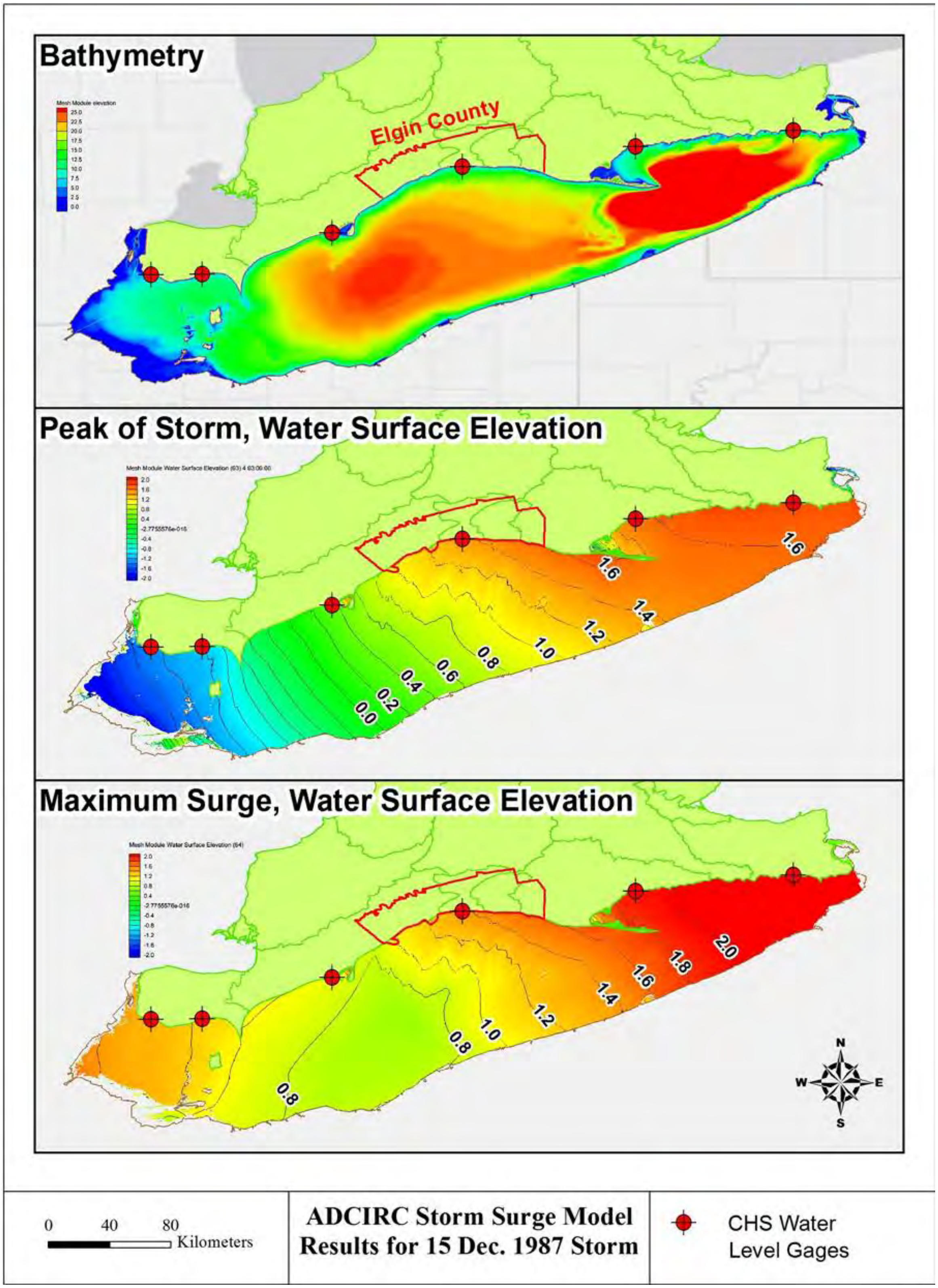


Figure 2.32 Storm Surge Elevation Estimates for the December 15, 1987 Storm

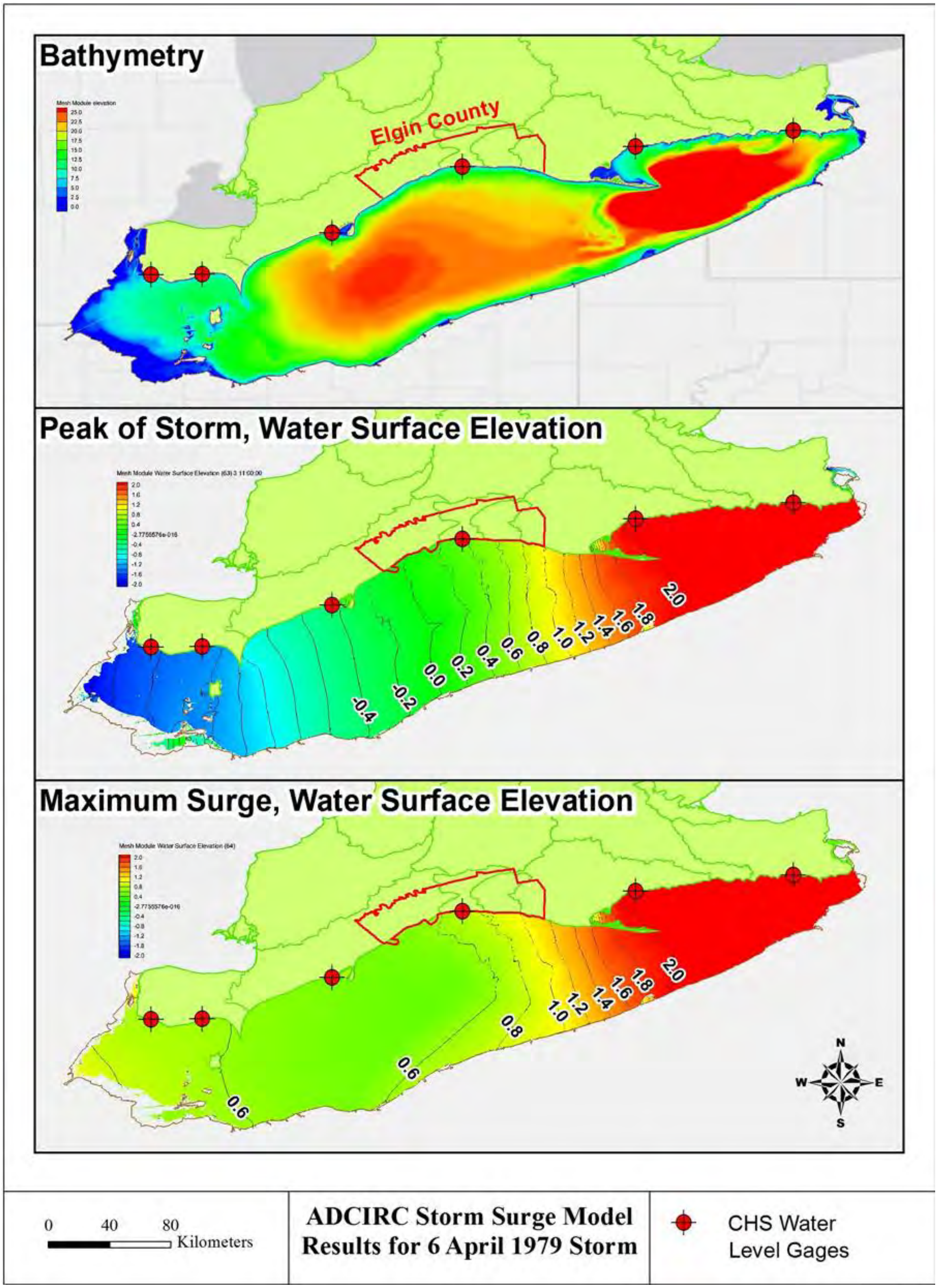


Figure 2.33 Storm Surge Elevation Estimates for the April 6, 1979 Storm

2.6 Geotechnical Considerations for High Bluffs

The high bluffs along the Elgin County coastline are continuously undermined by lakebed downcutting in the nearshore and toe erosion during wave attack. Consideration of these slope processes and the local soil conditions is necessary when establishing a stable slope allowance. This allowance is in turn utilized for the erosion hazard setback calculation, as specified in Section 4.3 of the Technical Guide.

Several of the 51 study sites were re-visited with geotechnical engineering staff from Terraprobe on October 9, 2014. West of Port Stanley, the eroding bluffs consist of glacio-lacustrine sediment with a high silt and clay content. This sediment was deposited in a glacial lake environment and is partially to fully consolidated. Therefore, many sections of the bluff are able to maintain a steep slope before they fail, as seen in the distance of Figure 2.34. Fractures in the bluff face can lead to large failures or topples, as pieces of the bluff face break off and fall into the lake. The soil can also lose its cohesive properties, often during heavy rainfall events or spring thaw events when the clay particles in the sediment absorb water. Eventually, the sediment absorbs too much water and turns into flowing sediment, spilling onto the beach as seen in the forefront of Figure 2.34.

Figure 2.34 Glacio-lacustrine Bluffs West of Port Stanley

East of Port Stanley, the majority of the eroding bluffs consist of a sandy lacustrine clay, with significantly less silt and clay compared to the soils to the west. Due to the sand content in the soil, there is less cohesive strength and the sediment is only partially consolidated. The constant wave attack at the toe of these bluffs keeps the bluff face in a constant state of instability. Slides and rotational slope failures result in large debris fans at lake level, as seen in Figure 2.35. In many cases, the slope failures are described as progressive, since the waves and currents are not able to fully erode the debris from the first failure before the second failure occurs and mixes with the first.

Figure 2.35 Eroding Bluffs at Site 48

In the absence of detailed site specific geotechnical studies to define the stable slope angle along the 90 km study limits, the standard 3:1 (Horizontal to Vertical) setback will be adopted for this SMP. Changes in the bluff crest elevation should be used to determine transitions in the width of the horizontal setback.

3.0 SHORELINE HAZARDS

Section 3.0 provides an overview of the erosion, flooding and dynamic beach standards and the procedures followed to map these regulated lands defined by the inland limit of each hazard.

3.1 Overview of Shoreline Hazards

Hazardous lands are defined in the PPS (MMAH, 2014) as "property or lands that could be unsafe for development due to naturally occurring processes." Along shorelines of the Great Lakes – St. Lawrence River System, this means the land, including that covered by water, between the international boundary, where applicable, and the furthest landward limit of the flooding hazard, erosion hazard or dynamic beach hazard limits.

The technical basis and methodologies for defining and applying the hazard limits for flooding, erosion and dynamic beaches are provided by the Technical Guide for Flooding, Erosion and Dynamic Beaches, Great Lakes – St. Lawrence River System and Large Inland Lakes (MNRF, 2001a). The basic procedures outlined in the Technical Guide (MNRF, 2001a) with some modifications have been included in subsequent documents, such as Ontario Regulation 97/04 ("Generic Regulation") and Guidelines for Developing Schedules of Regulated Areas (MNRF/CO, 2005). These methodologies have been applied in this study and are described in the following subsections.

It is important to note, as outlined in the Technical Guide (MNRF, 2001a), that the regulated hazard limits are generally to be mapped based on the assumption of no shoreline protection works in place. The clearly stated intent is that the mapped flooding, erosion, and dynamic beach hazard limits are to represent the underlying, ambient nature of the hazard and should not be modified by the presence of existing or proposed shoreline protection. The maximum limit of the hazards is utilized in determining the regulated area along Elgin County.

The PPS (2005) states that development and site alteration shall not be permitted within the dynamic beach hazard (3.1.2a) and areas rendered inaccessible during times of flooding, erosion and/or dynamic beach hazards (3.1.2c). Development in hazardous areas shall not be permitted where the use is institutional, essential emergency services, or hazardous substances (3.1.4).

3.2 Erosion Hazard

As discussed in Section 2.4, Elgin County features some of the highest bluff recession rates in the Great Lakes Region. Based on the classification in Section 4.5 of the Technical Guide, the majority of the recession rates in Elgin County fall within the very high (1.2 to 2.0 m/yr) to severe (> 2.0 m/yr) category. Therefore, defining and mapping the coastal hazard setback for the SMP is a critical activity to ensure future development is safe throughout the 100 year planning horizon.

When development is located on the tablelands of an eroding bluff, eventually the structural stability of the buildings will be compromised due to slope instability issues. And if not relocated, the building will eventually be destroyed, as was the case for the home in Figure 3.1. The home was eventually destroyed during a large slope failure.

Figure 3.1 Home Destroyed by Bluff Failure in the LTVCA (photo courtesy of the LTVCA)

3.2.1 Definition of Erosion Hazard

Calculation of the erosion hazard is a two-step process. In the first step, the erosion hazard is calculated as the sum of the stable slope allowance, plus the 100 year erosion allowance, and the discretionary additional 15 m (as determined by the CA) or a minimum erosion allowance of 30 m if sufficient recession data is not available. Figure 3.2 shows the erosion hazard limit as defined in the Technical Guide (MNRF, 2001a) and Understanding Natural Hazards (MNRF, 2001b). The approach used in the Generic Regulation is similar but the recession allowance is applied first, then the stable slope allowance is applied; for example:

> "the predicted long term stable slope projected from the existing stable toe of the slope or from the predicted location of the toe of the slope as that location may have shifted as a result of shoreline erosion over a 100-year period."

Both approaches will result in the same erosion hazard limit if the table land is flat, which is the case in Elgin County. For this study, the stable slope allowance was delineated first because slope stability is an immediate risk and the stable slope line was used to identify lands and infrastructure in a high risk zone (refer to Section 4.3.2 for further details). Development should not be permitted within the stable slope allowance.

The AARR plus the AASD is multiplied by the 100 year planning horizon to determine the erosion allowance. In locations where there is insufficient reliable recession information, such as an armoured shoreline, the Technical Guide (MNRF, 2001a) suggests a minimum 30 m setback distance to allow for future erosion along the Great Lakes-St. Lawrence River system. A diagram of the standard 30 m setback is provided in Figure 3.3. The adopted recession rates for this study were summarized in Section 2.4.3.

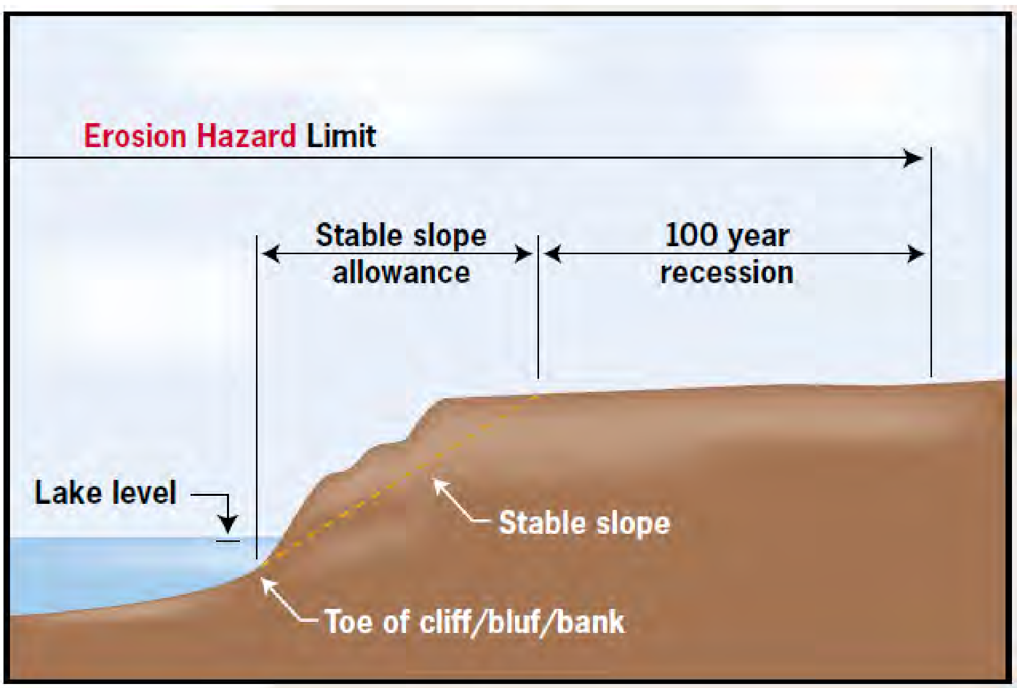


Figure 3.2 Erosion Hazard Limit with Reliable Recession Data (from MNRF, 2001b)

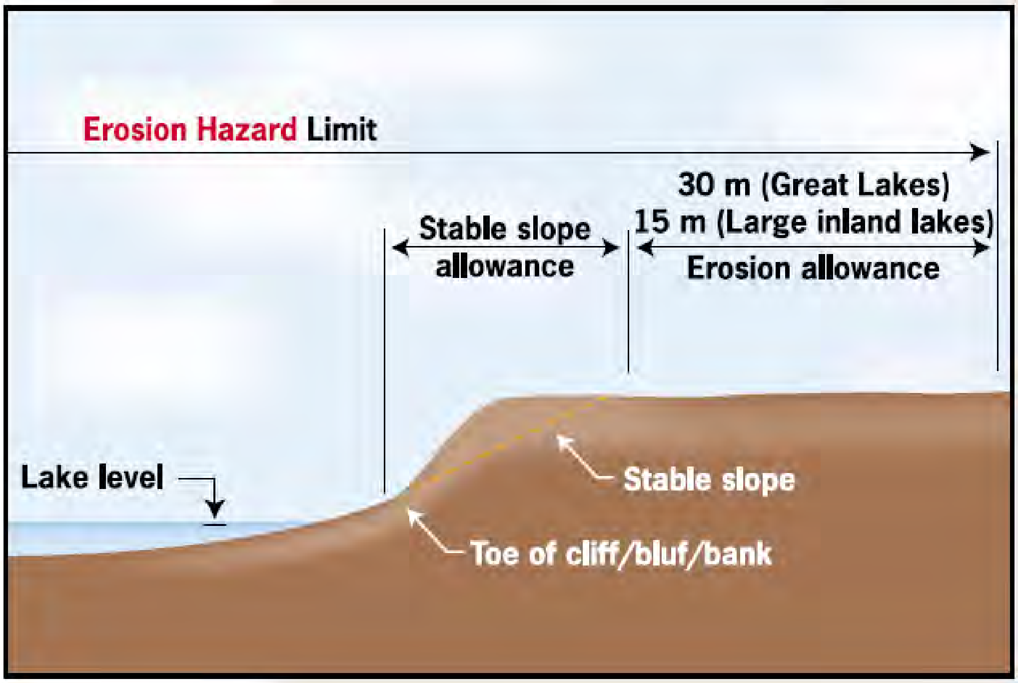


Figure 3.3 Erosion Hazard Limit Defined without Reliable Recession Data (from MNRF, 2001b)

3.2.2 Mapping the Erosion Hazard

The Technical Guide (MNRF, 2001a) recommends using a stable slope allowance of 3:1 (i.e., three times the bluff height, measured horizontally from the toe of slope) unless a geotechnical engineer provides a detailed site specific study. A slope stability allowance of 3:1 (horizontal:vertical) was used for the entire study area. A bluff crest and toe line was derived from the 1:2,000 scale 2010 Southwestern Ontario Orthophotography Project (SWOOP) contours and manually digitizing in GIS, providing a good estimate of the existing bluff conditions upon which to estimate the future erosion setback. The elevation difference between the toe and crest was calculated to establish the bluff height and the line segments were grouped according to 2 m elevation increments. When the bluff crest elevation changed by 2 m or at significant geomorphic features, such as a gully, a new stable slope setback was calculated based on the new bluff height and projected landward from the toe.

The erosion allowance was calculated by multiplying the sum of the AARR and the AASD by 100 and then added to the stable slope allowance. The recession rates were grouped according to large stretches of shoreline that featured similar erosion rates, as noted in Table 2.1.

In locations where the shoreline was already protected with shoreline protection, such as the port communities east of the Port Stanley and Port Burwell navigation channels, a 30 m erosion allowance was adopted. The SMP identifies the importance of regular maintenance on these shoreline protection structures.

3.3 Flooding Hazard

Coastal flooding in Elgin County is primarily focused on the low lying Port Communities, as infrastructure located on the tablelands above the bluff crest is not susceptible to flooding hazards. Refer to Figure 3.4 for an example of coastal flooding in the Lower Thames Valley Conservation Authority. The definition and mapping procedures to delineate the flooding hazards are described in the following sections.

Figure 3.4 Coastal Flooding in the LTVCA Watershed (photo courtesy of LTVCA)

3.3.1 Definition of Flooding Hazards

The flooding hazard is defined by the combination of the 100 year flood level and the flood allowance for wave uprush and other water related hazards, as depicted graphically in Figure 3.5. The 100 year flood elevations previously utilized by the Conservation Authorities (Table 2.4 in Section 2.5.3) were compared to an updated joint probability analysis using the latest data from the Port Stanley water level gauge and found to be a good estimate of the 100 year flood level. Therefore, the existing 100 year flood elevations in use by the CAs will be utilized to delineate the flooding hazard.

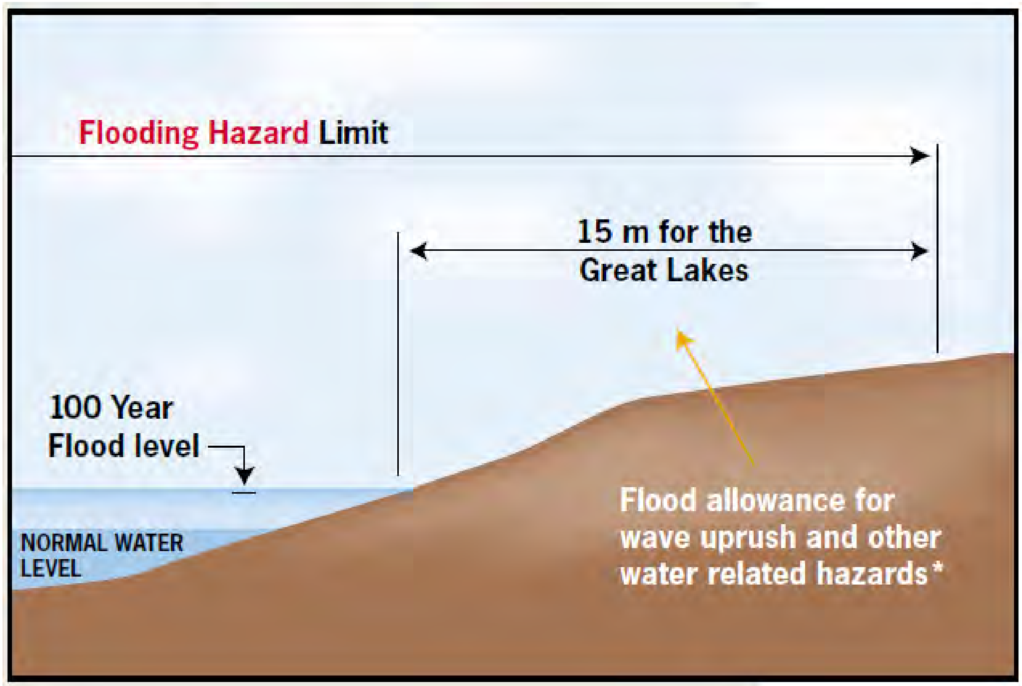


Figure 3.5 Flooding Hazard Limit for the Great Lakes Coastline (from MNRF, 2001b)

The Technical Guide (MNRF, 2001a) requires a flooding allowance of 15 m, measured horizontally from the location of the 100 year flood level, as noted in Figure 3.5, if a study using accepted engineering and scientific principles is not undertaken. The standard 15 m setback was adopted throughout Elgin County, with the exception of the Port Stanley community, which has a prior technical study.

3.3.2 Mapping of Flooding Hazards

The 100 year flood level is the sum of the mean lake level and storm surge with a combined annual probability of 1%. In any given year, there is a 1% chance the 100-year flood level will be equalled or exceeded. The existing 100-year flood level used to map the hazard limit within the CAs was verified in this study with a statistical analysis and numerical modeling of storm survey on Lake Erie. Refer to Section 2.5 for additional details on the technical methods.

The location of the 100 year flood level was mapped using the 1:2,000 scale SWOOP contours throughout the county, which were of sufficient scale and accuracy to locate the flood elevation. In a small portion of Port Glasgow a detailed survey provided data on the location of the 100 year flood level and in the Port Stanley community a detailed coastal flood study completed in 1996 (Shoreplan Engineering) provided site specific information. The technical findings from this detailed study (Shoreplan Engineering, 1996) were utilized to map the flooding hazard in Port Stanley.

Once the 100 year flood level was mapped, a 15 m buffer was applied in a landward direction to establish the Flood Hazard Limit. The limit of the regulatory line was mapped throughout the county; however, in most locations with a high bluff, the erosion hazard limit will be the governing setback.

3.4 Dynamic Beach Hazard

The beaches in Elgin County are important cultural, recreational and ecological features that require careful management and protection. The dynamic beach hazard recognizes that the land-water interface is a very dynamic environment in the Great Lakes due to wave erosion during storms and fluctuating lake levels. Refer to Figure 3.6 for a picture of the Port Bruce dynamic beach. Therefore, the standard includes an allowance for flooding, the dynamic nature of beach and dune environments, and long-term erosion. Since the beaches in the port communities of Elgin County are stable, the erosion component is not included in the dynamic beach hazard setback for this SMP.

Figure 3.6 Dynamic Beach west of Navigation Channel in Port Bruce

3.4.1 Definition of Dynamic Beach Hazard

The dynamic beach hazard involves the calculation of the cumulative impact of the flooding hazard, the erosion allowance and a dynamic beach allowance. In addressing these factors, the dynamic beach hazard is defined as:

- The landward limit of the flooding hazard (100-year flood level plus a flood allowance for wave uprush and other water related hazards) plus a 30 metre dynamic beach allowance or a distance determined by an accepted coastal study, plus 100-year erosion allowance if the shoreline is eroding (see Figure 3.7);

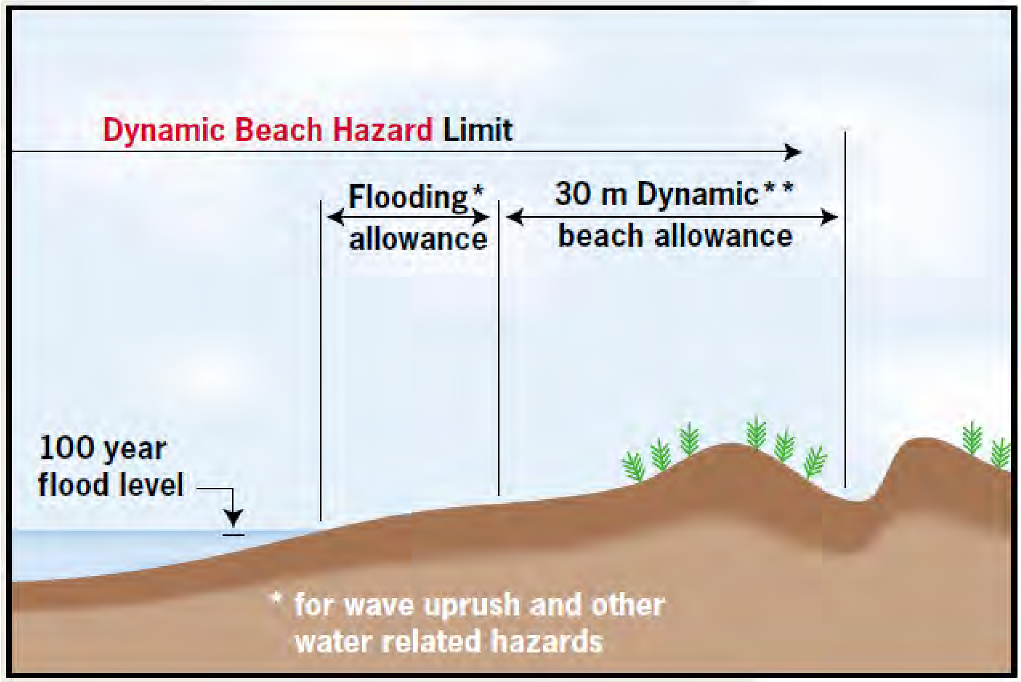


Figure 3.7 Dynamic Beach Hazard Limit

The 100 year flood level and the flood allowance represent the flooding hazard, as described in Section 3.3. The dynamic beach allowance is intended to permit the natural erosion and accretion of the beach/dune system in response to variable lake levels and storm events. The Technical Guide (MNRF, 2001a) requires a dynamic beach allowance of 30 m if no study using accepted engineering and scientific principles is undertaken. The sum of the combined flooding and dynamic beach hazard allowances is 45 m measured horizontally from the position of the 100-year flood level.

3.4.2 Mapping of Dynamic Beach Hazard

The term dynamic beach is used in the Technical Guide (MNRF, 2001a) to describe beach profiles which undergo changes on a broad range of time scales in response to changing wave, wind and water level conditions and to change in the rate of sediment supply. The dynamic beach hazard is only applied where: a beach or dune deposit exists landward of the water line, the beach or dune deposits overlying bedrock or cohesive material are equal to or greater than 0.3 metres in thickness, 10 metres in width and 100 metres in length along shoreline.

Dynamic beaches within the study area were identified in Port Stanley, Port Bruce and Port Burwell. An additional 30 m was added to the flooding hazard to map the dynamic beach hazard. While there are some beaches in Port Glasgow adjacent to the navigation channel to the marina, they are too small to meet the size requirements outlined above.

4.0 COASTAL MANAGEMENT

Section 4.0 summarized the recommended future approach to coastal management in Elgin County, including specific guidance for existing development, future development applications and special hazard considerations.

4.1 Overall Management Approach

Section 4.1 outlines the management approach for high bluffs, large fillet beaches, navigation channels, and the existing shoreline development in the port communities. The recommendations are consistent with the principles and objectives adopted for the SMP and were approved by the Steering and Technical Advisory Committees.

4.1.1 High Bluffs: Managed Retreat

The erosion rates within the study area are some of the highest in the Great Lakes region, as highlighted in Section 2.3.4. The map in Figure 4.1 documents the amount of land loss at Site 48 since 1978, which features an annualized erosion rate of 4 m/yr. Across Elgin County similar losses are not limited to agricultural land. Road networks become fragmented along the coast, buildings have to be relocated or abandoned, and utility lines require relocation. During the July 2014 site visit, a building relocation at Site 48 was observed, presumably due to the retreating bluff crest. Refer to Figure 4.2. This home on temporary piles is a good example of the ongoing response to the erosion risks in Elgin County. As noted in the old SMP for LPRCA (Philpott, 1989), past attempts at protecting individual lots have failed due to the very high erosion rates, lack of engineering design for shoreline protection, no consideration of lakebed downcutting, lack of flanking protection at the property boundaries, and engineering structure that are too small (i.e., length) given the severe rate of bluff recession at the site and on adjacent properties.

To assess the number of buildings at risk to erosion, the location of the 3:1 (V:H) stable slope was overlaid on the 2010 county-wide orthophotograph. A GIS database was developed for all primary (e.g. house with foundation) and secondary (e.g. outbuilding such as garage or mobile home that could be moved) buildings located between the stable slope line and the bluff crest. In total, 115 primary buildings and 55 secondary buildings are located within the 3:1 stable slope line in Elgin County. If an average value for the primary buildings and contents of $300,000 is assumed, this represents over $34 million in buildings presently at risk to erosion hazards.

When considering the future management approach to address the erosion hazards and associated risks for the High Bluff coastline in Elgin County, several options were considered: 1) construction of shoreline protection to slow down the long-term erosion rate, 2) relocation or abandonment of the asset, and 3) adoption of a planning horizon greater than 100 years (100 years is presently the duration mandated by the Conservation Authorities Act and PPS). The issue of constructing shoreline protection was investigated in the previous SMP for the KCCA. For example, a revetment design was developed for the east and west sides of Grand Canyon, west of Port Stanley. Given the very high costs of constructing shoreline protection along this eroding coast, the benefit cost ratio was 0.15 and 0.05 respectively. A ratio of greater than 1.0 is required to justify such a project based on avoided damages. In the case of the revetment design for Grand Canyon, the cost of the shoreline protection was 7 to 20 times more expensive than the real estate it would attempt to save. To put this in context for a riparian land owner, the cost of constructing shoreline protection would greatly exceed the value of the land and buildings you are attempting to protect. It is also worth noting that the Grand Canyon area features residential development. For agricultural lands, which have even lower land values, the benefit-cost ratios would be even less favourable.

When considering the feasibility of constructing shoreline protection on a lot-by-lot basis, it is also necessary to consider the objectives of the SMP, including maintenance of natural coastal processes, protection and restoration of coastal habitat, and no negative impacts attributed to new development. If shoreline protection was constructed along the High Bluff coast for a single lot, both near-field and far-field impacts will occur. Locally, there is the potential for negative impacts to adjacent lands that are not protected due to flanking erosion and regionally the supply of new material for the littoral sediment budget will decrease.

The primary downdrift impact associated with constructing shoreline protection is related to a reduction in the natural supply of sand and gravel for the littoral cell. As documented in Section 2.2, erosion of the bluffs generates the sand and gravel that is transported to the east and west in Elgin County to feed the depositional beaches at Long Point and Rondeau, respectively. The construction of shoreline protection, even a single lot, will reduce the supply of new sand and gravel. The previous SMP for the KCCA discussed the issue of cumulative impacts of armouring the shoreline but failed to reach a conclusion on whether the negative impacts with single lot shoreline protection were measurable or significant.

This issue was re-examined for the present SMP update within the context of the principles and objectives established for the plan. The negative impacts of single lot shore protection were considered significant and failed several objectives, including maintaining natural physical processes, protecting coastal habitat, and no negative impacts. The findings from the Colchester to Southeast Shoal littoral cell study (Baird, 2008) emphasized the impacts of cumulative impacts. For example, while the impacts of a single shoreline protection structure on the littoral sediment budget is difficult to quantify, the cumulative impacts of many lots over time are significant. Presently, 87% of the natural sediment supply to the Colchester to Southeast Shoal littoral cell in the western basin of Lake Erie has been lost due to shoreline protection, which is a significant negative impact. And these losses are based on the cumulative impacts of single lot by lot protection.

In summary, the construction of shoreline protection along the high bluff sections of Elgin County is not consistent with the principles and objectives of this SMP, the Provincial Policy Statement and the Conservation of Land, as mandated by Ontario Regulation 97/04. Therefore, it is recommended that no additional shoreline protection structures be permitted along the High Bluff coastline in Elgin County. The recommended approach is "Managed Retreat," which includes the following:

- Proactively mapping the future bluff crest position to inform riparian land owners of the hazards, both short and long-term. Updates should be generated approximately every five years corresponding to the collection of new county-wide orthophotographs.

- Inform land owners of the erosion hazards and risks to buildings in order to minimize damages and future losses.

- Relocate structures and critical infrastructure, such as roads, when the erosion hazard reaches a critical threshold (e.g. within the 3:1 stable slope setback).

- Experimenting with bio-engineering techniques to manage surface water, absorb soil moisture, and increase slope stability. Collectively, the combination of these approaches may reduce the long-term bluff erosion rate and the loss of tablelands, but will not address downcutting of the lake bottom.

- Pursue community based programs to implement vegetated buffer strips along the lake and plant these strips with water absorbing native vegetation, with the goal of slowing the long-term erosion rate.

In summary, new primary residences, major additions, or new shoreline protection structures are not recommended within the regulated area along the High Bluff coast. Refer to Section 4.1.1.1 for additional details on permissible and prohibited development activities for the High Bluff coast. Given that the high rates of erosion across Elgin County will continue indefinitely, even if new development is located inland of the regulated area, it will be threatened by erosion beyond the 100 year planning horizon. By allowing development inland of the 100 year setback, we are simply delaying the problem for future generations. Therefore, the County, Municipalities and CAs are encouraged to consider adopting a planning horizon longer than 100 years for the lands adjacent to the High Bluffs. Then, the burden of erosion mitigation won't be simply passed on to future generations. Another approach is to prohibit any further land subdivision for a buffer strip inland of the High Bluffs (e.g. 1 km) for residential development and focus on utilizing the land for agricultural purposes.

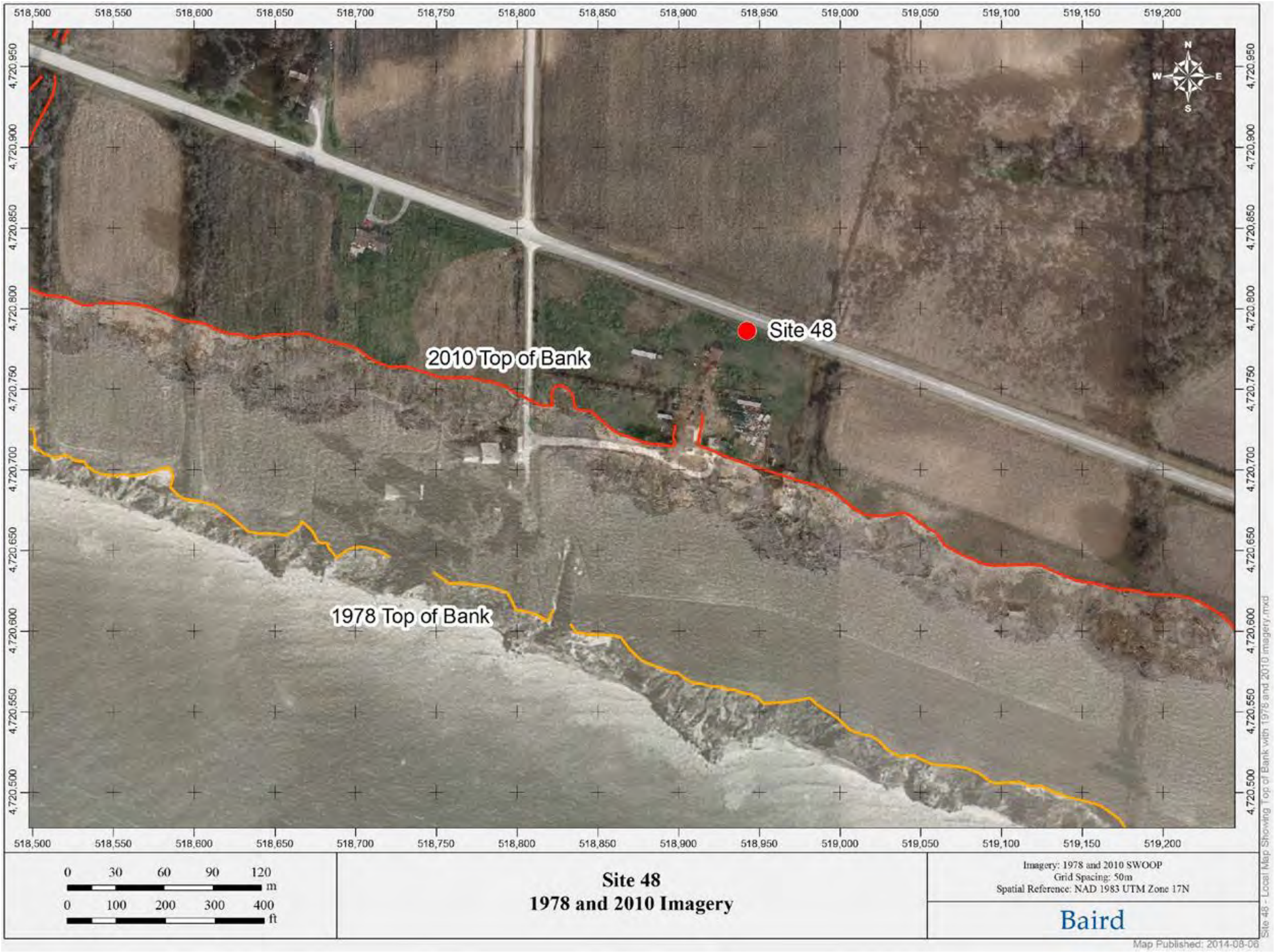


Figure 4.1 1978 to 2010 Top of Bank Recession at Site 48

Figure 4.2 Home on Temporary Piles (assumed relocation due to bluff recession)

4.1.1.1 Future Development Guidelines for High Bluffs

Recommendations for future development on regulated lands within the High Bluff reaches should be evaluated on an individual application basis to ensure the plan is consistent with the principles and objectives of this SMP. Table 4.1 summarizes different types of hypothetical development applications that may be brought forward in the future for the High Bluff reaches and whether they will be permissible or prohibited activities.

Table 4.1 Permissible and Prohibited Activities in High Bluff Areas

I - EXISTING DEVELOPMENT (in Erosion Hazard Areas)	
PERMISSIBLE ACTIVITIES *	**PROHIBITED ACTIVITIES**
Repair and Maintenance of Existing Buildings	Major Additions
Interior Alternations	Rebuilding of Existing Buildings if Destroyed by Flooding or Erosion
Minor Additions	
Rebuilding if Destroyed by Forces other than Flooding and Erosion	
Relocation of Existing Dwelling Inland Away from Hazard	
II - EXISTING VACANT LOTS (in Erosion Hazard Areas)	
PERMISSIBLE ACTIVITIES *	**PROHIBITED ACTIVITIES**
Technical Severance	New Development
Lot Consolidation	Creation of New Lots (Severance, subdivision)
III - ACCESSORY STRUCTURES (in Erosion Hazard Areas)	
PERMISSIBLE ACTIVITIES *	**PROHIBITED ACTIVITIES**
New Minor Structures	New Major Structures
New Deck	Swimming Pools
	New Septic Systems *
IV – SHORELINE ALTERATIONS (in Erosion Hazard Areas)	
PERMISSIBLE ACTIVITIES *	**PROHIBITED ACTIVITIES**
Repair Existing Shoreline Protection Structures on the Same Footprint	New Shoreline Protection
Replacement/Improvement of Existing Shoreline Protection on the Same Footprint	Fill Removal (Dredging)
	Fill Placement (Beach Nourishment)
** Permissible activities subject to site specific regulatory requirements as determined by the local Conservation Authority*	

4.1.2 Port Community Beaches: Protect Dune Habitat and Promote Public Access

Each of the four Port Communities feature jettied navigation structures, which protrude into the lake varying distances (e.g. 80 to 1,500 m). These structures have disrupted the natural flow of sediment along the coastline and trapped sediment in fillet beaches locally. Over time, two Provincial Parks (Port Bruce and Port Burwell) where established on these artificial beach deposits. Others, such as eastern and western fillet beaches in Port Stanley (Figure 4.3 and Figure 4.4 respectively) are popular public access nodes to the Lake Erie coastline.

Figure 4.3 East Fillet Beach at Port Stanley

Figure 4.4 West Fillet Beach at Port Stanley

The resulting beach deposits have become an important social and economic component of the Port Communities, providing public access to the lake, swimming facilities and land for commercial facilities (e.g. food/concessions). The Elgin County Official Plan (2012) recognizes the important role of beaches and one of the primary goals in the plan is to protect and enhance tourism and the recreational benefits associated with public beaches.

Public access to these beaches should be maintained in the future, with ongoing investments in facilities (e.g. washrooms), parking, and multi-use trails. Connectivity of the beaches to present and future development inland is encouraged through the use of trail networks. This is particularly important for future development so residents have easy access to the coastline of Lake Erie.

Coastal dunes are an important component of beach ecosystems in the Great Lakes and thus they should be protected from unnecessary foot traffic by beach users. Focusing access to the beach at select nodal areas with boardwalks over the dunes is an effective strategy. Refer to Figure 4.5 for a picture of a wooden boardwalk at the Port Burwell Provincial Park used to focus foot traffic and protect the fragile plant communities in the dunes.

Figure 4.5 Wooden Boardwalk at Port Burwell Provincial Park

The significance of these dune environments is the basis for the Dynamic Beach Standard and the protection they receive from future development. However, in some locations with dense development, such as the western fillet beach in Port Stanley, the dunes have been modified or removed. Refer to Figure 4.6. In addition to the important habitat the dunes provide, they also protect development from flooding hazards. If the dune in one location has been removed, it increases the vulnerability of the entire area to coastal flood risks. In such locations, the local governments and CAs should encourage local riparian landowners to restore the coastal dunes.

Figure 4.6 Port Stanley Beach Development with no Dune (looking south)

4.1.3 Navigation Channels: Maintain Flood Conveyance and Sediment Bypassing

The jettied navigation structures in the four port communities were initially constructed to improve navigation into the rivermouths and marina basins for commercial vessels and local fishing fleets. The safe refuge from Lake Erie storms provided the catalyst for further development of the port lands and they have supported a variety of industries (e.g. fish processing) and more recently recreational boating. Refer to Figure 4.7 for a picture of the navigation channel in Port Bruce.

Figure 4.7 View of Port Bruce Jetties and Navigation Channel Looking Upstream

Maintaining the hydraulic conveyance in these navigation channels is required to mitigate flooding risks and ice jamming upstream. The owners and operators of these structures and navigation channels are encouraged to regularly monitor channel depths and ensure flood conveyance is maintained.

Another important management consideration at the jettied navigation channels is sediment bypassing. As discussed in Section 2.2, sand and gravel eroded from the high bluff environments is transported along the coast to nourish local beaches and in some cases the large depositional features beyond the limits of Elgin County (e.g. Long Point and Rondeau sand spits). Sediment will accumulate at the tip of these jetties and in the actual navigation channel. Where possible, all of the sand and gravel sized sediment dredged from the navigation channels should be re-deposited on the downdrift beach or lake bottom. This will minimize impacts to the natural rate of sediment supply and transport along the coast, which is an important objective of this SMP.

In the future, any proposed modifications to the jettied structures at these ports should be carefully investigated to determine the impacts on the rate of sediment bypassing. Further, if future engineering modifications are proposed, they should be designed to maximize the rate of sediment bypassing. Trapping additional sediment is not consistent with the objectives of this SMP.

For example, at Port Burwell, it would appear the western jetty has been extended on two occasions while the length of the eastern jetty remains unchanged. Refer to Figure 4.8. This single jetty expansion approach at Port Burwell has continually increased the trapping potential of the western structures, while leaving the navigation channel susceptible to sedimentation during storm events from the east. Based on field observations, one zone of sediment accumulation is noted in Figure 4.8 (aerial view) and with a ground level photograph in Figure 4.9. These historical management decisions are not consistent with the objectives of this SMP and in the future a more holistic decision making framework that relies on the principles of ecosystem based management is required when modifying the engineering structures at the ports.

Figure 4.8 Port Burwell

Figure 4.9 Zone of Sedimentation Adjacent to the West Jetty

In the future, prior to commencing engineering design investigations to extend the harbour jetties or modify their configuration, the following technical investigations should be completed at a scale suitable to capture key physical processes, such as a littoral cell:

- Surveys of lake bottom depths and substrate conditions (geology).

- Quantify rates of sediment accumulation in the fillet beaches using historical and modern bathymetry and aerial photograph comparisons, including changes in rates over time.

- Rates of lakebed downcutting and bluff recession updrift and downdrift of the navigation channel.

- Documentation of long-term dredging and disposal records (quantity and location of disposal).

- Quantification of long-term wave climate using measured data or numerically generated time series.

- Estimates of gradients in longshore sediment transport based on local wave climate and impacts of the proposed modification.

- 2D or 3D hydrodynamic modeling at the navigation structures to estimate wave driven circulation and rates of sediment transport. It may be necessary to include flows and sediment concentrations from the rivers draining into the ports.

- Develop a sediment budget for the littoral cell, including rates of sediment supply from bluff recession, sediment trapped in the fillet beach, sediment accumulation in the navigation channel, dredging records, rates of sediment bypassing and accumulation in sediment sinks. Then, the sediment budget is used to investigate the impacts of the proposed modification to the navigation channel on downdrift erosion and the rates of sediment accumulation in sediment sinks.

- Investigate alternative configurations for the jettied harbour entrance to improve navigation, minimize future dredging costs and maximize sediment bypassing. This investigation will require numerical modeling.

- Consider other sediment bypassing alternatives, including mechanical dredging and bypassing with a barge, hydraulic dredging (where sediment is dug up from the lakebed hydraulically and bypassed in a slurry), and fixed bypassing plants.

4.1.4 Port Community Development: Hold the Line

Elgin County features four prominent port communities, including Port Glasgow, Port Stanley, Port Bruce, and Port Burwell. The sheltered waters of these ports are used for commercial, industrial, and recreation activities, and thus are an important economic component of the local economies.

Due to the long settlement history, there is a high density of commercial and residential development, supported by roads and utilities, along the coast. Given the high long-term erosion rate in Elgin County, some of this waterfront development is protected with engineering structures, such as rock revetments, steel sheet pile walls, and ad hoc structures (e.g. dumped concrete rubble). The shoreline protection is typically located on the downdrift (east side) of the port communities, since the western beaches feature a long-term accretion trend. This existing shoreline protection should be maintained to "Hold the Line" and stop any further erosion in these areas of high settlement density.

As discussed previously in this report and highlighted throughout the Elgin County (2012) Official Plan, new development should focus on existing settlement areas where municipal services are already provided and the shoreline is protected from coastal hazards by the jettied navigation channels, stable fillet beaches and existing shoreline protection structures. Further shore parallel or linear development along the eroding bluff crest should be discouraged. Where possible, community planning should focus on maintaining public open space along the lakeshore and connecting the existing and new residential areas to the lake with a multi-use trail system.

As documented in Section 2.2.2, the long-term erosion rate in Elgin County results in the permanent erosion and lowering of the cohesive lake bottom and the horizontal retreat of the bluffs. When shore parallel protection structures, such as revetments, are constructed to stop erosion and protect infrastructure such as homes, the lake bottom continues to erode. This is depicted graphically in Figure 4.10 and is referred to as lakebed downcutting. Eventually, the downcutting will undermine a sloping or vertical structure, leading to failure.

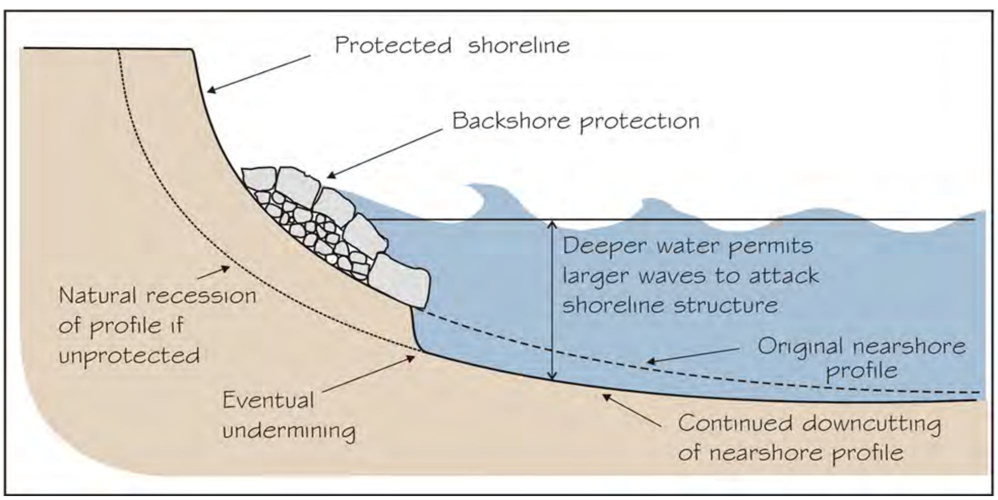


Figure 4.10 Lakebed Downcutting at the Toe of a Shore Parallel Structure

A picture of the revetment east of the navigation channel in Port Burwell is presented in Figure 4.11. This structure is approximately 500 m in length and followed by another smaller revetment or ad hoc structure at the creek mouth to the east. Based on discussions with the Technical Advisory

Committee, the ownership of this structure is not known and thus it seems unlikely routine maintenance is being completed. The ownership of this structure and other similar installations in Elgin County should be determined. A digital database noting the type and spatial location of all shoreline protection structures, including this revetment, was assembled as part of the background data collection for this SMP. This digital database could be expanded to include ownership and a point of contact information, thus serving as a useful tool to ascertain responsibility for future maintenance.

Figure 4.11 Armour Stone Revetment East of the Navigation Channel, Port Burwell

Shoreline protection structures also fail during wave overtopping events, which generally occur during storms at average to high lake levels. Flowing water over the crest can erode sediment from behind the structure, which in turn destabilizes the protection. Refer to Figure 4.12 for an example of cavity behind a stacked block wall in Port Stanley. This cavity appears to be related to insufficient drainage during wave overtopping events. While not affecting the overall structural stability of the wall today, over time if not mitigated the cavity will grow and eventually lead to structural failure and possibly shore erosion. Structures should be visually observed by the owner after every significant storm event and at least once a year, such as following the spring ice-out conditions.

Engineering structures will also fail due to age, which is referred to as degradation failures, since they were not designed to last forever. Refer to the dumped concrete rubble structure in Port Glasgow, as seen in Figure 4.13. Over time the concrete pieces will break, crumble and slide downslope, leaving the upper bank exposed to wave activity. Signs of crest erosion are evident in Figure 4.13 and it is important to note we have been in a period of low to average water levels on Lake Erie since 1999. During storms at high lake levels, these structures are more vulnerable to shore erosion. Given that there is no engineering design component to these ad hoc structures, they should be inspected regularly by the owners (e.g. monthly).

Figure 4.12 Cavity Behind a Concrete Block Wall in Port Stanley

Figure 4.13 Ad Hoc Concrete Rubble Protection in Port Glasgow

Following regular inspections, if visual signs of a failure are observed, the owner should retain the services of a qualified coastal engineer to design an appropriate repair. For substantial structural failures or sites where development is located close to the coastline, comprehensive site inspections are recommended by qualified professionals. Such inspections should include a survey of the toe and crest elevations, depths of the adjacent lake bottom, stone size measurements, evaluation of concrete or steel integrity, visual signs of toe or crest failures, etc. The condition of adjacent properties and structures should also be documented.

Given the proximity of existing development in the county to the shoreline protection and the steep bluffs in some cases, construction access may be limited. Community maintenance projects are encouraged where multiple land owners work together on a common engineering approach for the shoreline protection maintenance. This group approach may also reduce costs for the marine contractor, as mobilization costs are spread across multiple properties.

Permits for maintenance of existing shore parallel shoreline protection structures on the original footprint should consider the following:

- Condition of existing shoreline protection and remaining design life, along with the proximity of existing development (e.g. home) to structure(s).
- Condition of adjacent properties and potential implications of proposed maintenance.
- Site access for the maintenance and future maintenance requirements.
- Local geology and rate of historical lakebed downcutting at the structure toe.
- Structure design based on local wave conditions, storm surge and long-term lake levels.

In summary, the recommended management approach for the Port Communities is focusing future residential growth in these locations away from the regulated lands and holding the line by maintaining existing shoreline protection structures. New shoreline protection structures should not be permitted.

4.2 Additional Hazard Considerations

Based on the severity of the erosion hazards in Elgin County and the results of the geo-technical engineering review, two additional hazard mapping lines were developed during the study: Zone of Pending Failure and Zone of Higher Risk. A description and rationale for these hazard lines is provided in the following report sections.

4.2.1 Zone of Pending Failure

There are many natural factors that can trigger a large bluff failure in Elgin County, such as rapid spring melting of snow pack and thawing of frozen ground, heavy rainfall events, and large coastal storms that erode the bluff toe and destabilize the upper slope. Anthropogenic factors can also cause slope failures, including surcharging the bluff crest (temporarily with vehicles or permanently with structures), modifications to the bluff slope for trails/access to the water's edge, construction of irrigation ponds, open pit sand mining, etc. While the factors can be identified, pinpointing the actual time of a future failure is almost impossible without extensive instrumentation within the bluff stratigraphy to evaluate the geotechnical properties of the soils and location of the water table.

Based on our site observations and the geotechnical review completed for this study, the tablelands located in a 10 m buffer from the existing top of bank have been identified as a "Zone of Pending Failure". For this narrow strip of land located along the top of bank, it is not a question of "will" the land be lost due to a slope failure and erosion, it is just a question of "when." Since the timing of such a failure cannot be reasonably predicted for the 90 km shoreline of Elgin County, a line was generated with GIS software to note the location of a 10 m buffer along the bluff crest extracted from the 2010 orthophotograph. It should be noted that at the time this SMP was published, the 2010 bluff crest line is already five years old.

The location of the 10 m Zone of Pending Failure is noted on Figure 4.14 along the western boundary of Grand Canyon, west of Port Stanley. At the terminus of Grand Canyon Road, one building is just landward of the Zone of Pending Failure and the line passes through the eastern most residence. The unfortunate reality is the next major slope failure at the foot of Grand Canyon Road will likely destroy this building unless the structure is relocated.

At the Hickory Grove Campground in the Municipality of West Elgin, a large buffer strip exists between the exiting bluff crest and the first row of trailers. See Figure 4.15. Presently, this buffer protects the trailer park from any immediate dangers associated with bluff failures and there are no structures in the Zone of Pending Failure.

The Zone of Pending Failure is a non-regulatory line, in that there is presently no zoning, policy, or legislation that controls or limits the existing land use activities in this 10 m buffer strip. However, should the local governments desire to implement a zoning bylaw, for example, the mapping and concept of Zone of Pending Failure could be used to help develop and enforce a bylaw to protect local infrastructure and people from the hazards associated with bluff failures. Such a bylaw could also be used to educate riparian land owners and day visitors of the hazards associated with any activity in close proximity to an eroding bluff crest.

In the future, when a new county wide orthophotograph is obtained, a new 10 m offset should be generated from the bluff crest by the CA/Municipality partnership that generated this SMP to evaluate changes in the position of the Zone of Pending Failure. Then, new structures at risk can be identified and the riparian land owners notified accordingly.

Figure 4.14 Zone of Pending Failure at Grand Canyon Road, Township of Southwold

Figure 4.15 Zone of Pending Failure at Hickory Grove Campground, Municipality of West Elgin

4.2.2 Zone of Higher Risk - 3:1 (H:V) Setback

The bluff slopes within the study area are in a constant failure cycle due to continuous toe erosion of the slope by wave action and lakebed downcutting. Many of the slope failures within Elgin County, especially in the eastern half of the county, are referred to as progressive slope failures since the second failure occurs on top of the first and they blend together.

Recognizing the inherent instability of eroding coastal bluffs, Ontario Regulation 97/04 defines the erosion hazard as the stable slope measured from the existing toe of slope plus an allowance for 100 years of shoreline erosion. In the absence of site specific geotechnical engineering information on slope stability, Conservation Ontario (2005) define the stable slope angle as 3:1 (H:V) for hazard setback planning. Every 1 m of bluff height translates into a 3 m horizontal setback. For example, the stable slope setback for a 30 m high bluff is 90 m, measured landward from the existing stable bluff toe.

The 3:1 stable slope setback is included on all of the hazard maps generated for this study. Considering it defines the location where the land is safe from a bluff failure or slope instability, by definition everything between the stable slope setback and the present bluff crest is inherently unstable. Therefore, the 3:1 setback line is a useful mapping reference to evaluate erosion hazards and structures at risk. Refer to the position of the 3:1 stable slope setback line for the Grand Canyon area west of Port Stanley (dash-dot-dash red line) in Figure 4.16. The erosion hazard setback line is plotted as the red dashed line further inland. All future major development should be located landward of this dashed red line, as outlined in Table 4.1.

Based on the geotechnical review completed for this study, all the tablelands within the 3:1 stable slope setback have been classified as a Zone of Higher Risk. In other words, there is a high probability these tablelands will erode, as the slope materials are unstable at an inclination steeper than 3:1. A total of 115 primary buildings and 55 secondary buildings are located within this zone of higher risk in Elgin County. A database of the building centroids was generated as a deliverable for this SMP update. Further details on the location of these buildings are provided in subsequent sections of this SMP.

The members of the Steering Committee, Technical Advisory Committee and the Emergency Responders all agreed that further action was required by the County, Municipalities, and CAs to notify land owners with buildings in the Zone of Higher Risk. These locations should also be periodically monitored and the digital GIS mapping should be updated when new countywide orthophotography is obtained. Similar to the Zone of Pending Risk, passive recreational uses or other existing land use activities in the Zone of Higher risk are not regulated. Therefore, the 3:1 stable slope setback line is presently a non-regulatory line with respect to existing development. However, for proposals dealing with new development, the 3:1 setback line is part of the formula used to define the location of the regulated lands.

Figure 4.16 Zone of Higher Risk, Grand Canyon Road, Township of Southwold

Based on numerous meetings with the staff from the Conservation Authorities, Municipalities, and Elgin County, a policy gap was identified for properties that are in close proximity to the top of bank due to ongoing erosion processes. In most cases, these homes were constructed many decades ago, long before the development of the present policy regime, when the top of bank was much further lakeward. However, the ongoing erosion process has now brought the top of bank within close proximity to the existing development. Since the regulatory authority of the CAs pertain to new development on hazardous lands, not existing development that becomes threatened due to erosion and bluff recession over time, there is presently no regulatory or policy regime to address this development at risk.

Local building officials are required to assess the structural stability of building foundations under present conditions at the site, not the impacts to a building if a failure happens in the future. For example, provided the homes in Figure 4.16 that are located close to the bluff edge are not presently threatened by structural instability, there is limited ability of building officials to identify a structure as unsafe to occupy. Therefore, at this time it would appear that building officials have limited authority over structures located in the Zone of Pending Failure or Zone of Higher Risk, unless the structural stability of the building is presently compromised. However, solutions to these policy gaps for both the building officials and CA representatives can be pursued and should be a priority activity. These land owners should be made aware of the risks associated with existing development in the Zone of Higher Risk and be provided with information on options to relocate structures away from the hazards.

4.2.3 Emergency Response Considerations

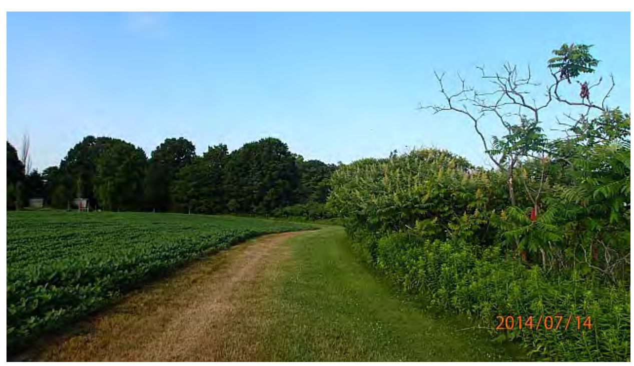
Based on the meetings with emergency responders in Elgin County, the 89 hazard maps have been made available to representatives from the Police, Fire and Emergency Management Services. In addition, the digital mapping for the Stable Slope Allowance and the Erosion Hazard Limit will be delivered to the county and municipal governments and the emergency responders. While the County does have an Emergency Response Plan (2015), it is primarily focused on roles and responsibilities for elected officials and emergency response agencies in the event of an emergency situation (e.g., storms, fire, hazardous spills, power failures, strikes and disorder). However, the Emergency Management Civil Protection Act (EMCPA, 2006) defines an emergency as:

> "a situation or an impending situation that constitutes a danger of major proportions that could result in serious harm to persons or substantial damage to property and that is caused by the forces of nature, a disease or other health risk, an accident or an act whether intentional or otherwise"

Based on this definition, a building located in the Zone of Pending Failure may represent an "impending situation," since there is the potential for substantial property damage and harm to individuals if they are in the home when a slope failure develops. Officials from Elgin County are encouraged to further investigate the use of their Emergency Response Plan to notify riparian land owners of the hazards and risks associated with buildings and land use activities within the Zone of Pending Failure.

4.3 Best Management Practices for Riparian Land Owners

Section 4.4 provides a visual summary of information on existing land use activities that exacerbate coastal hazards and alternative best management approaches. Stakeholders are encouraged to use this information as a guide only, and seek out professional guidance, and site specific information to address local concerns.

AGRICULTURAL LAND USE ALONG BLUFF CREST	
<u>DON'T</u>: Crop right to the edge of the bluff crest -avoid cultivating land and cropping right to the bluff crest -maintain tile drain outlets so they don't drain down the bluff face. Should outlet at beach level	
<u>DON'T</u>: Dump rubble and debris over the bluff crest -debris on the bluff crest will not mitigate slope erosion. In fact, it could accelerate the erosion process by surcharging (adding weight) to the slope and blocking groundwater discharge locations -the debris will eventually end up in the lake and pollute the nearshore environment, which is critical habitat and the source of our drinking water	
<u>DON'T</u>: Throw or mound grass clippings and/or brush/branches over the bluff edge -the concentrated grass clippings and vegetation smother native vegetation underneath, limit drying between precipitation events and impede overland drainage. All these unanticipated consequences can accelerate slope erosion.	
<u>DO</u>: Maintain a Vegetated Bluff Strip and Encourage Bluff Crest Vegetation -utilize vegetated buffer strips, vegetate bluff slope and ensure tile drains reach the beach (i.e. don't exit mid-slope) -considering taking narrow strips of land next to the bluff out of production and naturalize. The lost revenue from cropping the land might be small versus the savings in avoided erosion	

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<tr><th colspan="2">STRUCTURES ALONG THE BLUFF CREST</th></tr>
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<u>DON'T</u>: Locate Permanent Structures Close to the Bluff Crest

-large permanent buildings can surcharge the bluff crest and initiate slope failures. These types of structures should be located landward of the erosion hazard limit

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<u>DO</u>: Locate Light Movable Structures Landward of the Zone of High Risk

-Lightweight gazebo provides enjoyment of lake views and can be easily relocated

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<u>DO</u>: Maintain a Vegetated Buffer Strip between Movable Buildings/Trailers and Promote Vegetation on the Bluff Slope

-maintain a vegetated buffer between the bluff crest and movable structures, such as trailers

-monitor changes in the bluff crest position and have a retreat plan in place to re-locate structures when they are within the 3:1 (H:V) stable slope allowance

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TEMPORARY USAGE OF BLUFF CREST	
<u>DON'T</u>: Occupy the Bluff Crest for Any Reason -the bluffs can fail at any time and these failures cannot be predicted -the bluff crest should not be used for any reason, even passive day use	
<u>DO</u>: Use Signage to Make the Hazards Known -avoid all activities along the bluff crest, even walking or temporary viewing	

PROMOTE NATURAL/NATIVE VEGETATION ALONG BLUFF CREST AND ON SLOPE	
<u>DON'T</u>: Maintain a Mowed/Manicured Lawn Right to the Bluff Edge -without water absorbing native shrubs and trees, water from rainfall events flows quickly to the bluff edge and leads to slope failures -lawns have shallow root systems and don't bind together the soil	
<u>DO</u>: Encourage Native Vegetation on the Bluff Crest and Slope -plant water tolerant native vegetation on the crest and slope to absorb moisture (e.g. Sumacs and Dogwoods)	

MAINTENANCE OF AGRICULTURAL DRAINS IN ERODING BLUFFS	
DON'T: Underestimate the need for monitoring and maintenance following construction -the drainage schemes will not function without regular maintenance due to the high bluff erosion rates in Elgin County -do not design and/or construct a project without professional engineering support	
DO: Regularly inspect the drainage scheme, budget for future maintenance, and implement repairs -regular monitoring for all drains that traverse the bluff slope should be implemented by the owner -ensure the water is conveyed to the beach, not down the bluff slope -maintenance costs should be factored into the initial capital budget to ensure funds are available for the inevitable repairs -have a contingency plan to address failure of the drainage scheme following a bluff erosion event -seek profession engineering services to design and implement maintenance repairs of the drains	

Other useful references for assessing hazards and mitigation alternatives include:

- National Sea Grant Resilience Toolkit includes a number of useful references to help homeowners assess and mitigate coastal risks.

  http://seagrant.noaa.gov/WhatWeDo/ResilienceToolkit.aspx

- In addition, the Technical Guide for Great Lakes – St. Lawrence River System and Large Inland Lakes, includes useful information and references for identifying and addressing coastal hazards.

  http://www.iwsstore.ca/publication_4.asp

5.0 LOWER THAMES VALLEY CONSERVATION AUTHORITY SHORELINE MANAGEMENT PLAN

The LTVCA manages a large watershed that includes a significant portion of the Lake Erie coastline. This SMP addresses the LTVCA shoreline that falls within Elgin County, as noted on Figure 1.1 and reproduced in Figure 5.1. The background for this SMP update is summarized, along with the management approach for the various shoreline reaches, mapping of regulated lands and additional policy considerations.

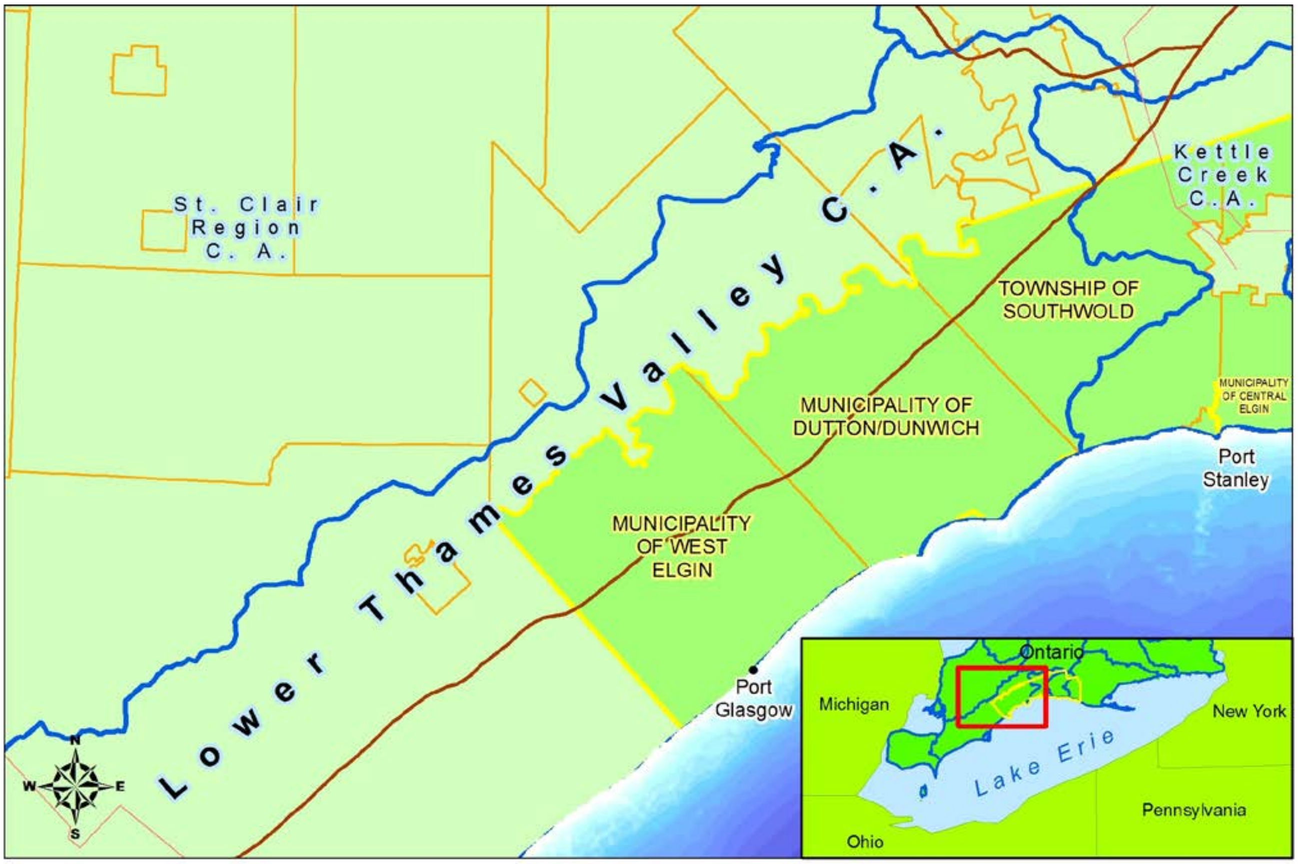

Figure 5.1 Portion of LTVCA within Elgin County

5.1 Introduction

As noted in Section 1.4, the LTVCA along with the other three CAs with jurisdiction in Elgin County have jointly developed a consistent shoreline management approach for the north shore of Lake Erie with officials from the County and Municipalities. Several important principles guided the development of this SMP, including integrated coastal zone management, ecosystem based planning and management, along with protection of natural heritage and the conservation of land.

Refer to Section 1.5 for a full description of the principles and objectives used to guide the development of this SMP.

Based on these guiding principles and the technical studies completed for this SMP update, a series of objectives were developed to support decision making on the management approach for the coastline. The key objectives include:

- Maintaining physical processes along the coast.
- Protection and restoration of coastal habitat.
- Focusing future development in the Port Communities.
- New development must not create negative impacts of any kind.
- A standardized interpretation of the SMP across Elgin County (to the degree local conditions permit).
- Regular communication on coastal hazards and associated risks to riparian land owners and stakeholders at large.
- Maintain public access to the coastline in perpetuity in the Port Communities.

The majority of the LTVCA coastline in Elgin County has been classified as High Bluff, as noted in Figure 5.2. In Port Glasgow, two additional shoreline reaches were identified to characterize the conditions at the marina and the high density development to the east. The management approach for these shoreline reaches is described in the following sections of this SMP.

The shoreline management approach for the three shore reaches within the LTVCA is described below in the following sections of the SMP.

Figure 5.2 Classification of the Coastline in Elgin County

5.2 LTVCA High Bluffs

The approach to calculate historical recession rates for the LTVCA high bluff shoreline was described in Section 2.4. The erosion rate established for the majority of this reach was 1.0 m/yr, which translates into a horizontal setback of 100 m, measured landward from the stable slope allowance. The stable slope allowance is a horizontal setback equivalent to three times the bluff height. For the very eastern portion of the LTVCA jurisdiction along Lake Erie (east of the Talbot Creek Ravine), the erosion rate increases to 1.6 m/yr.

Future development should be directed to areas outside of the shoreline hazard, as defined by the erosion hazard limit. Guidance for limited development activities in the regulated area is provided in Table 4.1 of Section 4.1.1.1. Existing buildings that are threatened by slope instability or erosion should be relocated away from these natural hazards. As noted in Figure 5.3, a total of 73 primary buildings and 18 secondary buildings were identified within the 3:1 stable slope setback. These structures are spread out throughout the LTVCA coastline and should be monitored in the future.

No development is safe within the 3:1 stable slope setback and as such, owners of such assets (e.g. buildings) should be notified. A new policy could be developed in keeping with the Elgin County Emergency Response Plan and local zoning bylaws that prohibit occupation of such dwellings, particularly those within 10 m of the bluff crest (the Zone of Pending Failure). At any time in the future, the land within this zone and any assets could be completely lost in the next bluff failure. Due to the severity of these hazards, it is advised that all activities be directed to a location further inland, including recreational pursuits, trails, temporary parking, sitting of mobile recreational vehicles, etc.

In addition, road infrastructure that exists within the 3:1 stable slope setback is not safe and the County and Municipalities are encouraged to review the transportation network along the coast to ensure safe access to dwellings and for emergency response personnel. The mapping from this SMP could be used to assist with long-term planning for the transportation network along the coast in the LTVCA.

5.3 LTVCA Reach 1 – Maintain Flood Conveyance and Sediment Bypassing

Reach 1 in the LTVCA includes the mouth of Sixteen Mile Creek, the Port Glasgow Marina navigation channel, and the adjacent fillet beaches. The area has been used to access the Lake Erie shoreline for more than 100 years, with the present marina basin constructed around 1960 (Shoreplan, 2006).

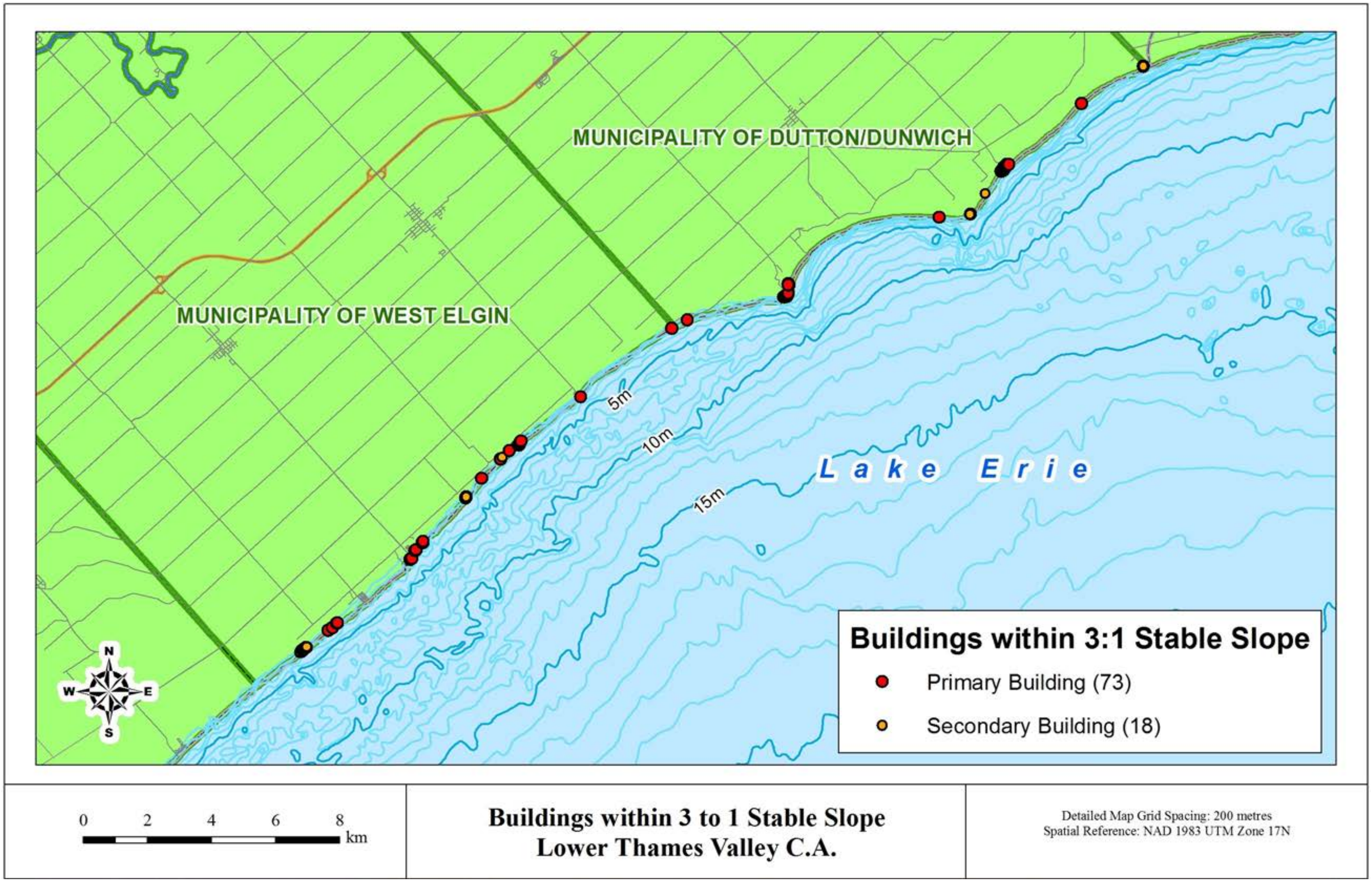

Figure 5.3 Location of Buildings within the 3:1 Stable Slope Allowance (Zone of Higher Risk)

Maintaining the flood conveyance of Sixteen Mile Creek is an important management objective for LTVCA Reach 1 to minimize future flooding risks. Any future plans to modify or expand the harbour jetties to the interior marina basin must consider future impacts to local beaches and in particular the conveyance of Sixteen Mile Creek. Sediment bypassing is another important consideration at Port Glasgow, as maintaining natural coastal processes is a key objective of this SMP. Any future modifications to the navigation channel must ensure there are no negative impacts to sediment bypassing and the supply of littoral material to downdrift beaches.

All sediment dredged from the navigation channel should remain in the littoral system. Sediment should not be mined/harvested from the beach, as such a practise will impact the downdrift beaches and may impact long-term bluff erosion rates.

The Port Glasgow Marina, boat launch, and the adjacent fillet beaches provide an access node to Lake Erie for the residents in the western half of Elgin County. The dock is used by anglers (see Figure 5.4) and a gravel trail is located along the water's edge to the east of the marina basin. These facilities should be maintained and enhanced to benefit all the residents in western Elgin County and beyond. There is potential to locate future residential development landward of the regulated area (e.g., on the flat tablelands) in Reach 1, since this area is already protected from erosion hazards and new development could be linked to the Port Glasgow waterfront with a trail network.

Figure 5.4 Fishing from Jetty at Port Glasgow

5.4 LTVCA Reach 2 – Hold the Line

The shoreline in Reach 2 is protected by dumped concrete rubble, as seen in Figure 5.5. Beaches are very narrow or non-existent. While dense vegetation exists behind the concrete rubble, this should not be confused as an indication of a stable beach and bluff. Numerous active groundwater seeps were observed at the base of the bluff and future geotechnical engineering studies may be required to investigate slope stability hazards.

Figure 5.5 Concrete Rubble Shoreline Protection East of Navigation Channel, Port Glasgow

The ownership of this structure should be ascertained by the landowners and a regular maintenance schedule developed. During high lake levels, the deteriorating concrete rubble will provide minimal erosion protection and the existing trail will be susceptible to erosion. If this ad hoc erosion protection structure fails, then the bluff behind will be very susceptible to erosion and slope failures.

The lands below the bluff and around the mouth of mouth of Sixteen Mile Creek are susceptible to flooding during periods of high lakes and storm activity. The flooding hazard limit is defined by the 175.4 m CGVC'28 datum plus a horizontal setback of 15 m. Future development must be located landward of the flooding hazard limit.

Above the vegetated bluffs in Reach 2, the tablelands are occupied by two trailer parks. In general, the roads and trailers are set back from the bluff crest and not within the Zone of Higher Risk (3:1 Stable Slope Line). Refer to Figure 5.6. However, three locations are noted on Figure 5.7 (white arrows) where a private road and/or trailers are within the Zone of Higher Risk. The bluffs should be regularly monitored in these locations.

Figure 5.6 Buffer Strip between Vegetated Bluff Crest and Road/Trailers

Figure 5.7 3:1 Stable Slope (red dash-dot line) and 100 Erosion Hazard Setback (red dashed line). White Arrows Identify Roads/Buildings in the Zone of Higher Risk

Provided the shoreline protection is maintained in Reaches 1 and 2 in the future, the tablelands in Port Glasgow should be the focus of future residential and commercial development in the area, as opposed to single lot development along the eroding bluff crest. The shoreline is protected from erosion and flooding hazards and public access to the coast already exists. In addition, focusing growth in this area is consistent with the Elgin County Official Plan.

5.5 Mapping for Hazardous Lands

The hazardous lands for this portion of the LTVCA are mapped on Sheets 1 to 35 and provided in Appendix D. Two hazards, erosion and flooding, are depicted on the maps. As discussed, the flooding hazard is defined by the 100 year instantaneous lake level (175.4 m, CGVD'28), plus a 15 m horizontal setback.

The erosion setback is defined by the 100 year erosion rate (100 m for Sheets 1 to 32, and 160 m for Sheets 33 to 35), plus the 3:1 stable slope allowance. A sample of the hazard mapping is provided in Figure 5.8 (Sheet 32). There are no buildings on this sheet located within the 3:1 Stable Slope Setback (Zone of Higher Risk). However, there is a pond in the middle of Sheet 32 that warrants some discussion. A portion of the pond is located within the 3:1 stable slope setback, which means the slope is inherently unstable and could fail at any time. If large enough, a slope failure could destroy the pond and result in the formation of a new gully or ravine. Not only would the benefits of the pond be lost but a new erosional feature (the ravine) would now be in close proximity to an important access road, farm buildings and dwellings.

A similar sequence of events is documented in Section 8.0 of this report, where an open pit sand mine located on the bluff top turned into a large ravine when erosion of the bluff face broke through into the sand pit. This site (pond on Sheet 32) should be monitoring carefully by the land owner, as decommissioning of this pond may be necessary to avoid aggravating local hazards.

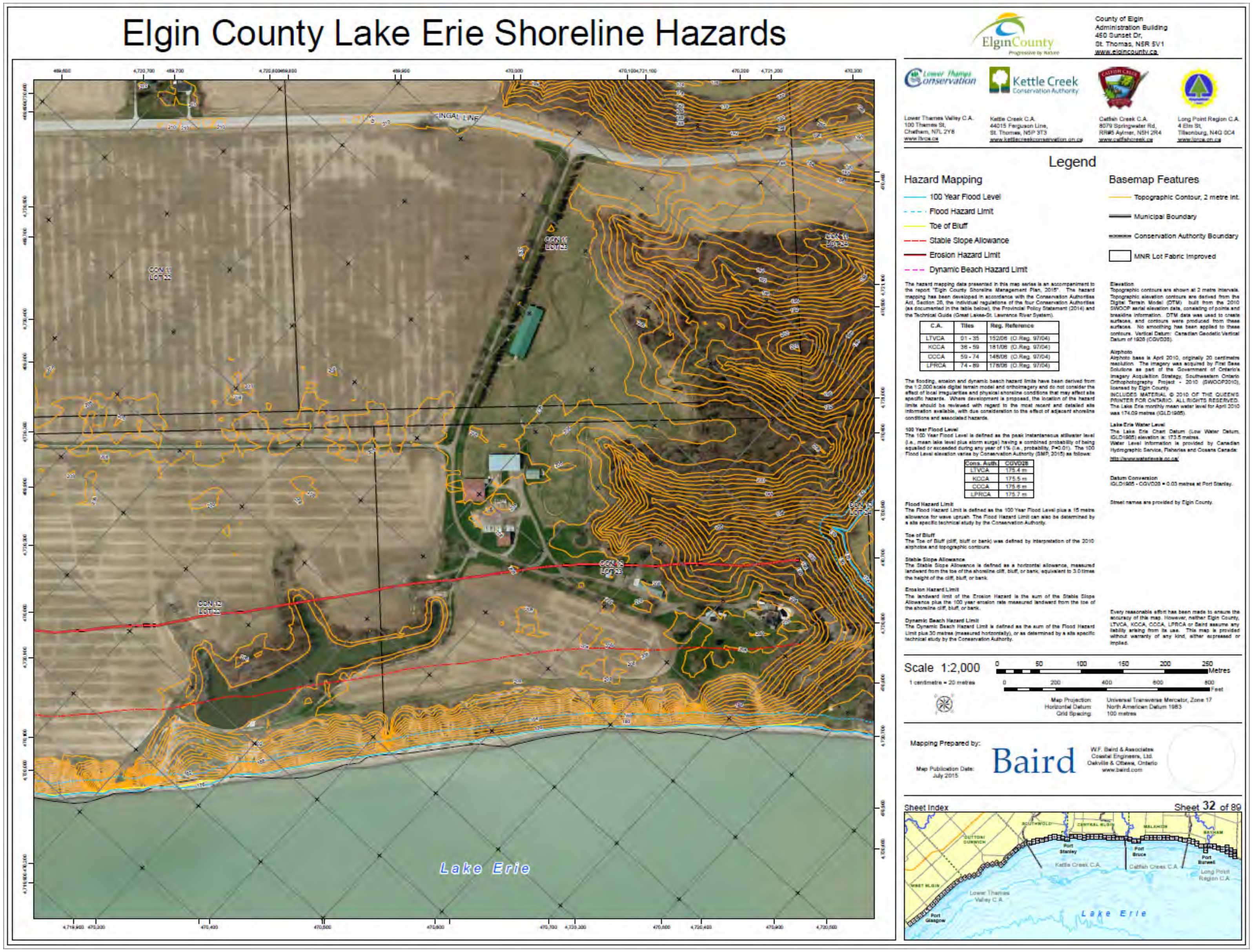

Figure 5.8 Sheet 32 West of the Talbot Creek Ravine

6.0 KETTLE CREEK CONSERVATION AUTHORITY SHORELINE MANAGEMENT PLAN

The previous SMP for the KCCA (Philpott, 1989) has served as a management guide for more than 25 years. This updated SMP builds on the historical information in the old SMP and the new technical analysis completed for this investigation. Figure 6.1 maps the limits of the KCCA watershed and coastline within Elgin County.

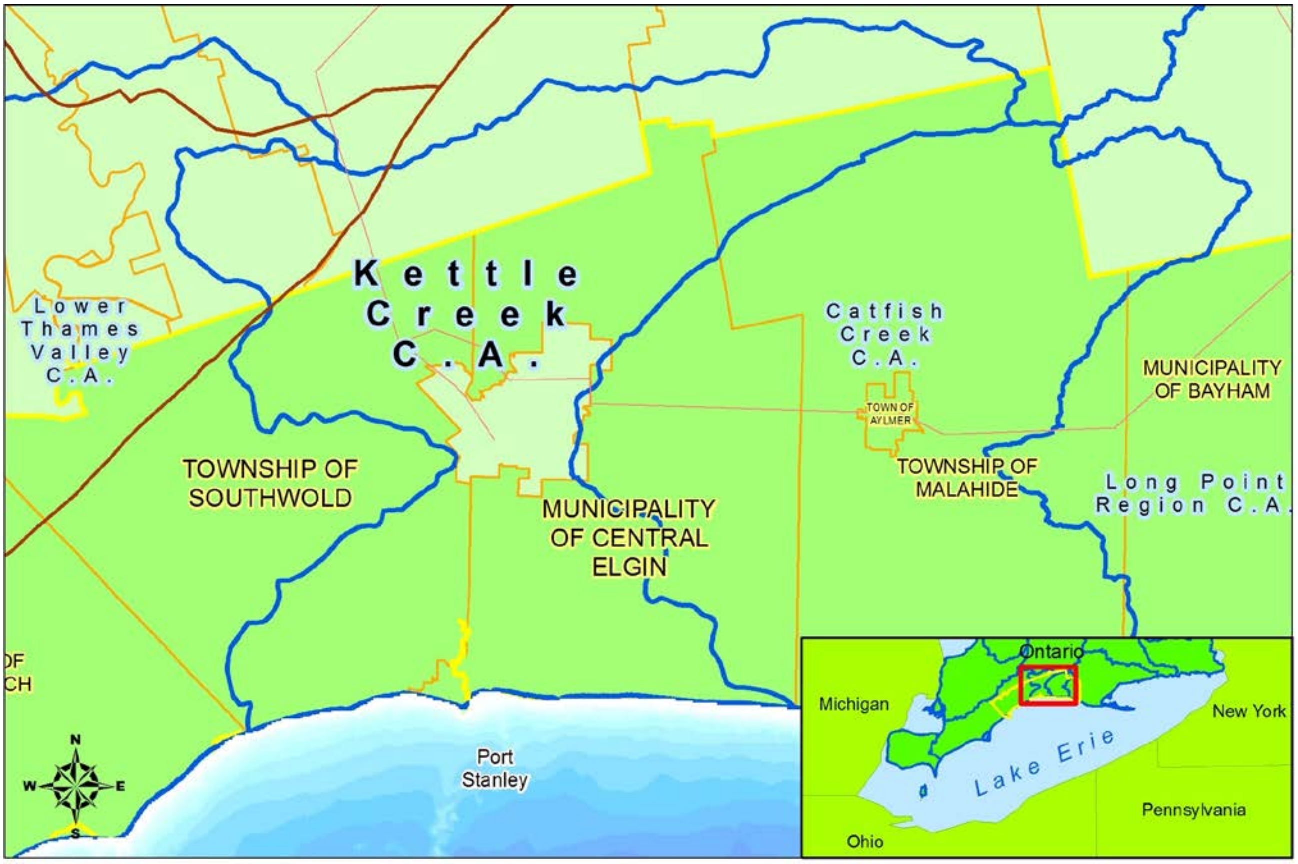

Figure 6.1 Limit of KCCA Watershed and Coastline within Elgin County

6.1 Introduction

As noted in Section 1.4, the KCCA along with the other three CAs with jurisdiction in Elgin County have jointly developed a consistent shoreline management approach for the north shore of Lake Erie with officials from the County and Municipalities. Several important principles guided the development of this SMP, including integrated coastal zone management, ecosystem based planning and management, along with protection of natural heritage and the conservation of land. Refer to Section 1.5 for a full description of the principles and objectives used to guide the development of this SMP.

Based on these guiding principles and the technical studies completed for this SMP update, a series of objectives were developed to support decision making on the management approach for the coastline. The key objectives include:

- Maintaining physical processes along the coast.
- Protection and restoration of coastal habitat.
- Focusing future development in the Port Communities.
- New development must not create negative impacts of any kind.
- A standardized interpretation of the SMP across Elgin County (to the degree local conditions permit).
- Regular communication on coastal hazards and associated risks to riparian land owners and stakeholders at large.
- Maintain public access to the coastline in perpetuity in the Port Communities.

The majority of the KCCA coastline in Elgin County has been classified as High Bluff, as noted in Figure 6.2. In Port Stanley, four additional shoreline reaches were identified to characterize the conditions of the local beaches, port, and existing shoreline development. The management approach for these shoreline reaches is described in the following sections of this SMP.

The shoreline management approach for the five reaches that characterize the KCCA coastline is described in the following sections of the SMP.

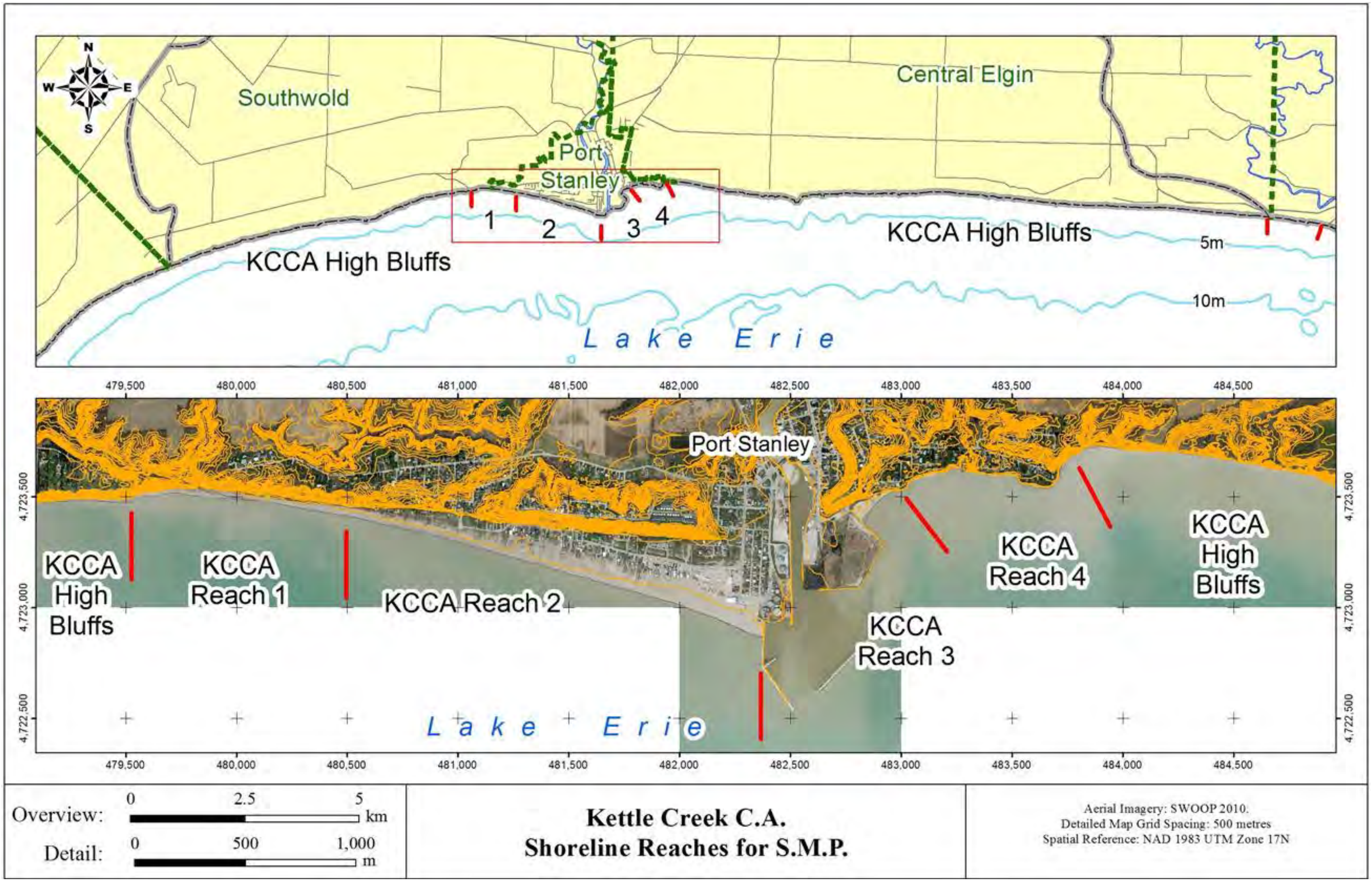

Figure 6.2 Shoreline Reaches for KCCA SMP

6.2 KCCA High Bluffs – West and East of Port Stanley

The approach to calculate historical recession rates for the KCCA high bluff shoreline was described in Section 2.4. The erosion rate for the high bluffs to the west of Port Stanley was 1.6 m/yr, which translates into a horizontal setback of 160 m, measured landward from the stable slope allowance. The stable slope allowance is a horizontal setback equivalent to three times the bluff height. Between Port Stanley and the Elgin County Pumping Station, the erosion rate is 3.7 m/yr. From the Pumping Station to the eastern boundary of the CA, the erosion rate for the high bluffs is 2.2 m/yr.

Future development should be directed to areas outside of the shoreline hazard, as defined by the erosion hazard limit. Guidance for limited development activities in the regulated area is provided in Table 4.1 of Section 4.1.1.1. Existing buildings that are threatened by slope instability or erosion should be relocated away from these natural hazards. As noted in Figure 6.3, a total of 28 primary buildings and 12 secondary buildings were identified within the 3:1 stable slope setback. These structures are spread out throughout the KCCA coastline and should be monitored in the future.

No development is safe within the 3:1 stable slope setback and as such, owners of such assets (e.g. buildings) should be notified. A new policy could be developed in keeping with the Elgin County Emergency Response Plan and local zoning bylaws that prohibit occupation of such dwellings, particularly those within 10 m of the bluff crest (the Zone of Pending Failure). At any time in the future, the land within this zone and any assets could be completely lost in the next bluff failure. Due to the severity of these hazards, it is advised that all activities be directed to a location further inland, including recreational pursuits, trails, temporary parking, sitting of mobile recreational vehicles, etc. Refer to Figure 6.4 for an example of a residence in close proximity to the eroding bluff crest.

In addition, road infrastructure that exists within the 3:1 stable slope setback is not safe and the County and Municipalities are encouraged to continue their review the transportation network along the coast to ensure safe access to dwellings for residents and emergency response personnel. The mapping from this SMP could be used to assist with long-term planning for the transportation network along the coast and emergency response.

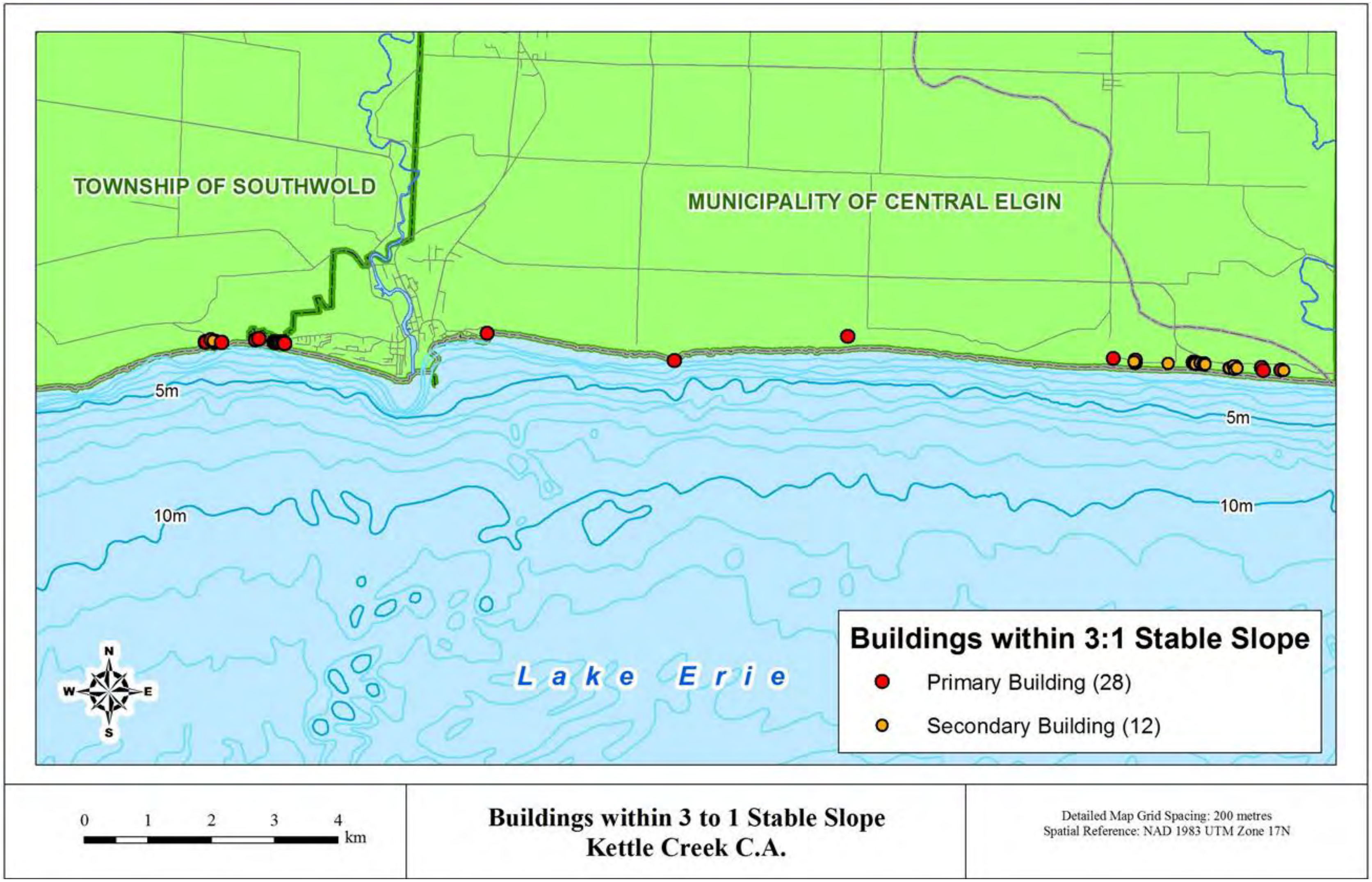

Figure 6.3 Location of Buildings within the 3:1 Stable Slope Setback (Zone of Higher Risk)

Figure 6.4 Building in Close Proximity to the Eroding Bluff Crest

6.3 KCCA Reach 1 – West of Public Beach

KCCA Reach 1 is a transition area from the eroding high bluffs to the west and the stable fillet beach in Port Stanley to the east. Refer to Figure 6.2 for the limits of Reach 1 and Figure 6.5 for a ground level picture. At present, the sand beach is narrow and disappears at the western limit of the Grand Canyon Ravine. Although the back of the beach is heavily vegetated with pioneer shrubs and small trees, the eroding bluff crest is still visible in many locations. Refer to Figure 6.6 for an example. The lack of mature trees on the bluff slope indicates that the period of stability along the beach has been relatively short lived in Reach 1.

Figure 6.5 Narrow Beach in KCCA Reach 1

Interestingly, in the old SMP for the KCCA a portion of Reach 1 was classified as the High Bluffs (see Figure 1.2, Philpott 1989), which attests to the fact that the shoreline trend is changing due to the accreting fillet beach. In other words, the shoreline trend has changed from erosion to accretion. However, it is also important to note that Lake Erie has been in period of low to average lake levels for the last 15 years. If high lake levels return, the recently accreted beach in Reach 1 could erode leaving the bluff toe and slope susceptible to wave attack and erosion.

Figure 6.6 Former Eroding Bluff Crest in KCCA Reach 1

The recommended management approach for KCCA Reach 1 is maintenance of the natural vegetation at the back of the beach and on the bluff slope. Over time, the vegetation will help stabilize the slope and bluff crest. However, until the beach width increases dramatically, Reach 1 should be monitored on an annual basis. In addition, only a narrow sliver of bluff separates the Grand Canyon Creek from the open lake at the western end of Reach 1. When this section of bluff erodes, the opening to the creek valley will increase dramatically, further jeopardizing the development along Grand Canyon Road.

No structures or development should take place on the beach or bluff crest. Future development applications on the tablelands inland of the bluff crest will be subject to policies governing activities on regulated lands, including seeking professional engineering advice on the stability of the bluff slope. Regular monitoring of the bluff crest position should occur in Reach 1, as many of the existing buildings are within the 3:1 stable slope setback.

6.4 KCCA Reach 2 – Public Beach

Reach 2 is a 1.8 km long fillet beach on the western side of the navigation channel in Port Stanley. The western portion of Reach 2 features less residential development and more natural beach and dune conditions. Refer to Figure 6.7. The beach width increases in an easterly direction as does the degree of residential and commercial development. The dunes are smaller or absent completely for the eastern half of Reach 2. Refer to Figure 6.8.

The beach and dune system in Reach 2 is a popular tourist destination in Port Stanley and thus an important part of the local economy in this port community. In addition, a healthy beach and dune system also provide natural protection from coastal flooding. These two important aspects of KCCA Reach 2 were examined in detail in the Port Stanley Beach Management Study (Shoreplan Engineering, 1996). The basic principles of beach management have not changed substantially in 20 years and thus the recommendations from that investigation remain valid today. Development is not permitted on the sand beach from the water's edge to landward limit of the dynamic beach hazard limit, which encompasses the majority of the dune ecosystem.

Figure 6.7 Beach and Dune Conditions in the Western Half of KCCA Reach 2

Figure 6.8 Wide Beach Conditions in the Eastern Half of KCCA Reach 2

Foot traffic through the dunes to access the lake should be directed to pathways in nodal areas, such as parking lots. Grooming of the beach should be minimized, as it negatively impacts the development of native dune vegetation and the associated habitat. Where possible, land owners, local government, and the Conservation Authority should work together to implement dune restoration projects, as they provide important habitat to local flora and fauna and flood protection during severe storm events.

Landward of the dynamic beach hazard limit, the 1996 Beach Management Study (Shoreplan Engineering) identified areas of land known as Zone 2 and Zone 3, where the potential for coastal flooding and wave impacts exist due to the flat nature of the beach at Port Stanley. These areas are also referred to as Modified Regulatory Flood Standard and Regulatory Flood Standard, respectively. Specific development guidelines were outlined in the 1996 report, including locating building additions and development on vacant lots on the least exposed portion of the lot (e.g., northern limit of lot). The recommendations for Zones 2 and 3 remain valid and have been adopted for this SMP update.

An important overall objective of this SMP for Elgin County is to discourage construction of buildings along the eroding bluff and focus high density development in the port communities. Specifically, new development should be focused inland of stable shoreline segments, such as Reach 2. These developments should be connected to a publically accessible lakeshore with a multi-use trail network.

6.5 KCCA Reach 3 – Harbour Lands and Little Beach

Collectively, the harbour jetties, navigation channel, abandoned port lands, and the eastern fillet beach (Little Beach) are part of KCCA Reach 3. The multiple management objectives for this reach are summarized.

Maintaining flood conveyance in Kettle Creek and between the offshore breakwaters is an important objective for Reach 3, as reductions in channel depths and thus conveyance could increase riverine flood risks. In addition, any future modifications to the engineering structures either within the confined navigation channel or the outer breakwaters must not reduce the hydraulic conveyance of the river, increase sedimentation rates, or both. For example, if sedimentation rates increase in the outer basin, flood conveyance may decrease, which in turn could increase potential riverine flooding.

The estimated volume of sediment trapped in this fillet beach, based on the surface area of this depositional feature and assuming a depth of sedimentation from -8 m to +2 m, is 4.7 million m^3 of sand and gravel. This estimate does not include any sediment trapped in the navigation channel and historically dredged and disposed in deep water or in sediment containment facilities. Without the construction of the original jetties at Port Stanley and subsequent expansions, this sediment would have been spread across the littoral cell to the east and deposited in the Long Point sand spit.

Given the objective of maintaining natural coastal processes, protection of coastal habitat, and avoiding negative impacts associated with development, the future operation of the navigation channel should ensure all littoral sediment naturally bypasses the Port Stanley harbour.

In keeping with the objectives of focusing growth in the Port Communities and maintaining public access to the waterfront, any redevelopment of the old port lands within Reach 3 should ensure a public multi-use trail system along the water's edge is integrated into the overall land use plan. Presently, a structural assessment of the port infrastructure is completed at roughly five year intervals. This forward looking monitoring should continue and a detailed coastal assessment should be added in the further to investigate potential flooding and erosion hazards if/when re-development is proposed on the old port lands. The study should include a review of lakebed downcutting at the toe of the existing shoreline protection, stability of the existing armour stone, and the ability of the structure to withstand wave overtopping events during high lake levels. The potential flood risks will also require further investigation, including the threat of wave overtopping and ponding inland for any proposed future development.

Little Beach is located on the eastern side of the harbour jetties and features a wide gently sloping beach at the present lake level. During higher lake levels, the waterline will migrate inland significantly. The previous SMP (Philpott, 1989) suggests the beach was formed with sediment dredged from the navigation channel. Present management practices with the dredged sediment are unknown but a stockpile was observed in the parking lot adjacent to Little Beach. When the winds are from the west and southwest, Little Beach provides a sheltered alternative to the main beach at Port Stanley in Reach 2. The beach should be maintained in the future for public access to Lake Erie. The promotion of dune vegetation is encouraged to increase the elevation of the beach, which will help mitigate the potential negative impacts of a prolonged period of high lake levels. Alternatively, an artificial dune restoration project could be planned and executed at Little Beach.

Figure 6.9 Little Beach in Port Stanley, Looking East

6.6 KCCA Reach 4 – Orchard Beach

KCCA Reach 4 features high density residential development and shoreline protection structures at the water's edge. During the July 2014 field visit, no beaches were observed in Reach 4. Refer to Figure 6.10 for a typical picture of the shoreline conditions. Without the shoreline protection, this reach would feature a long-term erosion rate. Therefore, it is imperative that the riparian landowners regularly inspect their existing shoreline protection and complete maintenance when required.

Figure 6.10 Existing Dumped Concrete Rubble in KCCA Reach 4

In the future, shoreline protection maintenance will be required to address degradation of these structures, and should be permitted provided the repair or replacement are contained within the footprint of the present structure. New shoreline protection structures are not recommended for Reach 4. However, limited types of new development are permitted in the erosion hazard area provided they are supported with the appropriate technical studies. Given that site access for construction equipment will be a challenge due to the high density development and lack of beach, a coordinated maintenance project across the entire length of Reach 4 should be pursued. Not only will a single engineered approach be more successful in the long-term, it will be more cost effective.

It is also worth noting that at the boundary between Reach 4 and the High Bluffs to the east, special consideration must be given to the future evolution of the armoured shoreline and eroding bluffs in this region. For example, flanking erosion at the end of the revetment and continued erosion of the High Bluffs to the east may result in future hazards to the existing development in this area.

Provided there is a commitment to long-term maintenance of the existing shoreline protection, future growth should be encouraged landward of the shoreline in Reach 4. This growth is already happening along East Road and is consistent with the Elgin County Official Plan.

6.7 Mapping for Hazardous Lands

The hazardous lands for the KCCA Lake Erie shoreline are mapped on Sheets 35 to 59, and provided in Appendix E. The erosion, flooding, and dynamic beach setbacks are depicted on the maps, collectively defining the hazardous lands along the Lake Erie shoreline for the KCCA. The limit of the dynamic beach setback and flooding hazard limit (176.8 m contour) were adopted from the 1996 Beach Management Study (Shoreplan Engineering). A sample of the hazard mapping for the KCCA Reach 2 beach is provided in Figure 6.11 (Sheet 44). There is no erosion hazard setback for Reach 2 and the limit of the hazardous lands is defined by the recommendations in the Beach Management Study (Shoreplan Engineering, 1996).

The erosion setback is defined by the 3:1 stable slope allowance, plus the 100 year erosion rate. Between Port Stanley and the Elgin Pumping Station, the 100 year erosion rate is 370 m. From the Pumping Station to the eastern limit of the CA, the 100 year erosion rate is 220 m. The hazardous lands on Sheet 59 are presented in Figure 6.12, which also covers the boundary between the KCCA and CCCA. One building is located within the 3:1 Stable Slope Setback along Dexter Line. Since the 2010 photography used for the base hazard mapping was collected, a portion of Dexter Line has been relocated and a longer term plan to relocate the road further inland is under consideration.

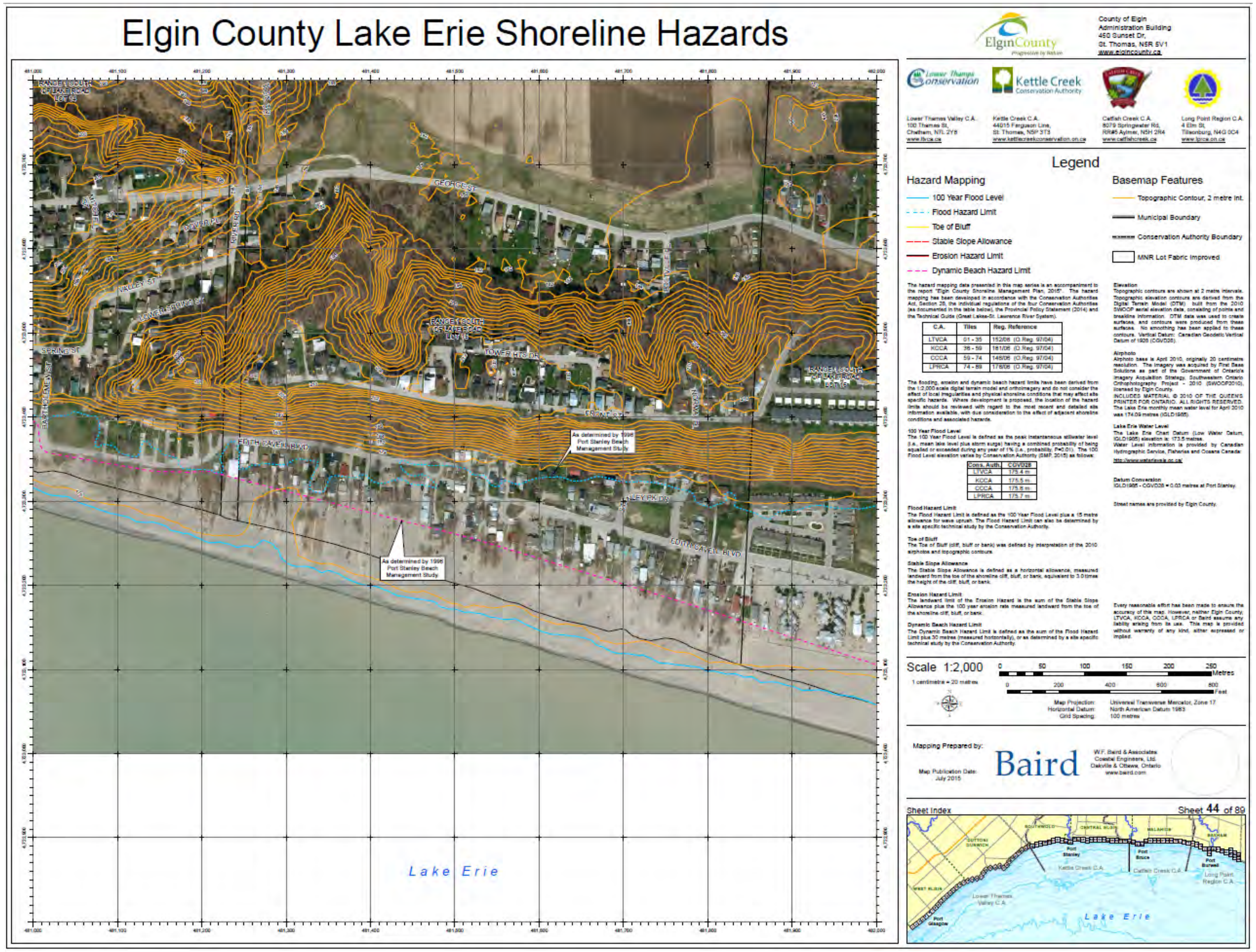

Figure 6.11 Hazardous Lands on the Port Stanley Fillet Beach, KCCA Reach 2 (Sheet 44)

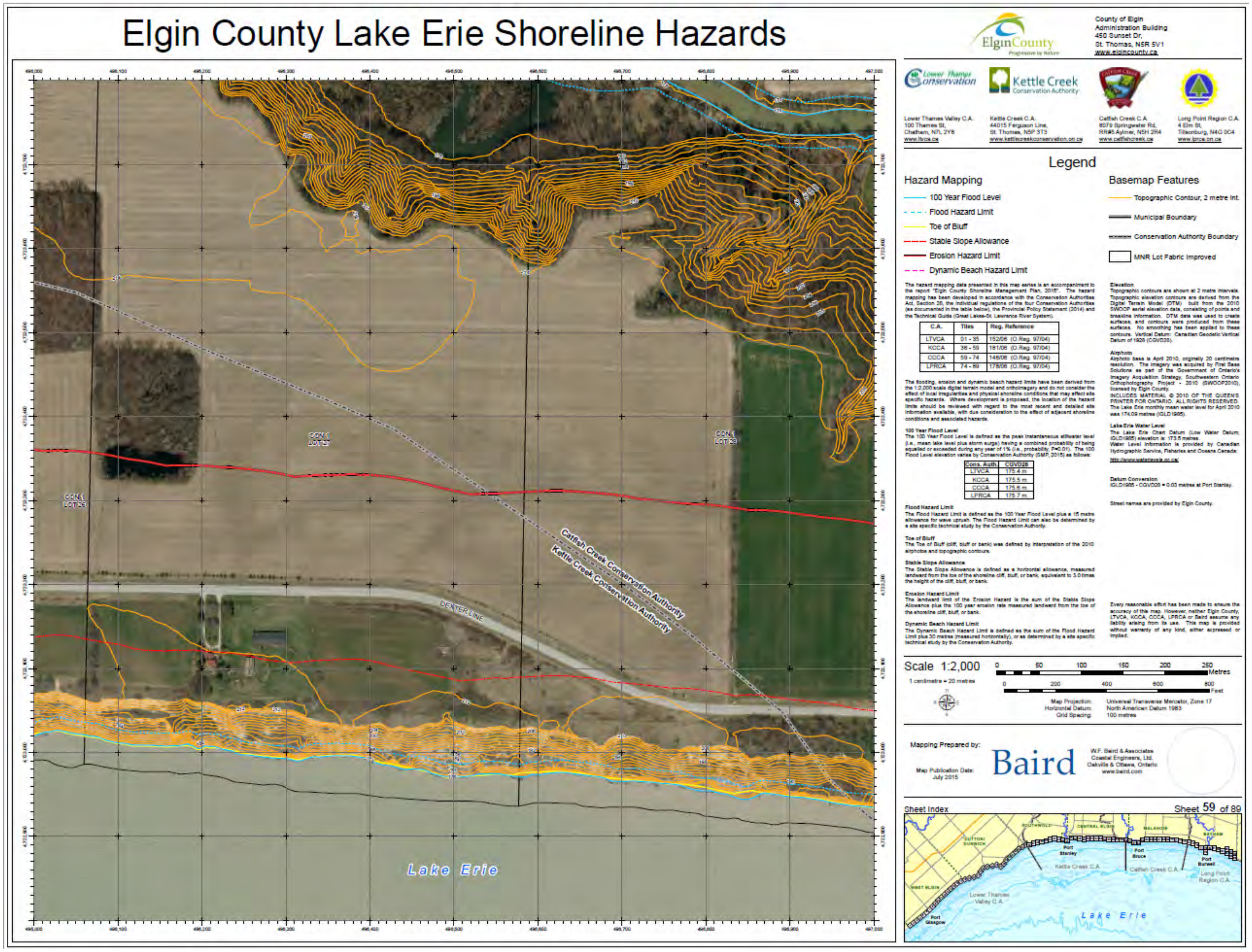

Figure 6.12 Hazardous Lands for High Bluffs at Boundary of KCCA and CCCA (Sheet 59)

7.0 CATFISH CREEK CONSERVATION AUTHORITY SHORELINE MANAGEMENT PLAN

The previous SMP for the CCCA (Philpott, 1991) provided management direction for new development along the coast of the CA for more than 20 years. This updated SMP builds on the historical information in the old plan and the new technical analysis completed for this investigation. Figure 7.1 maps the limits of the CCCA watershed and coastline within Elgin County.

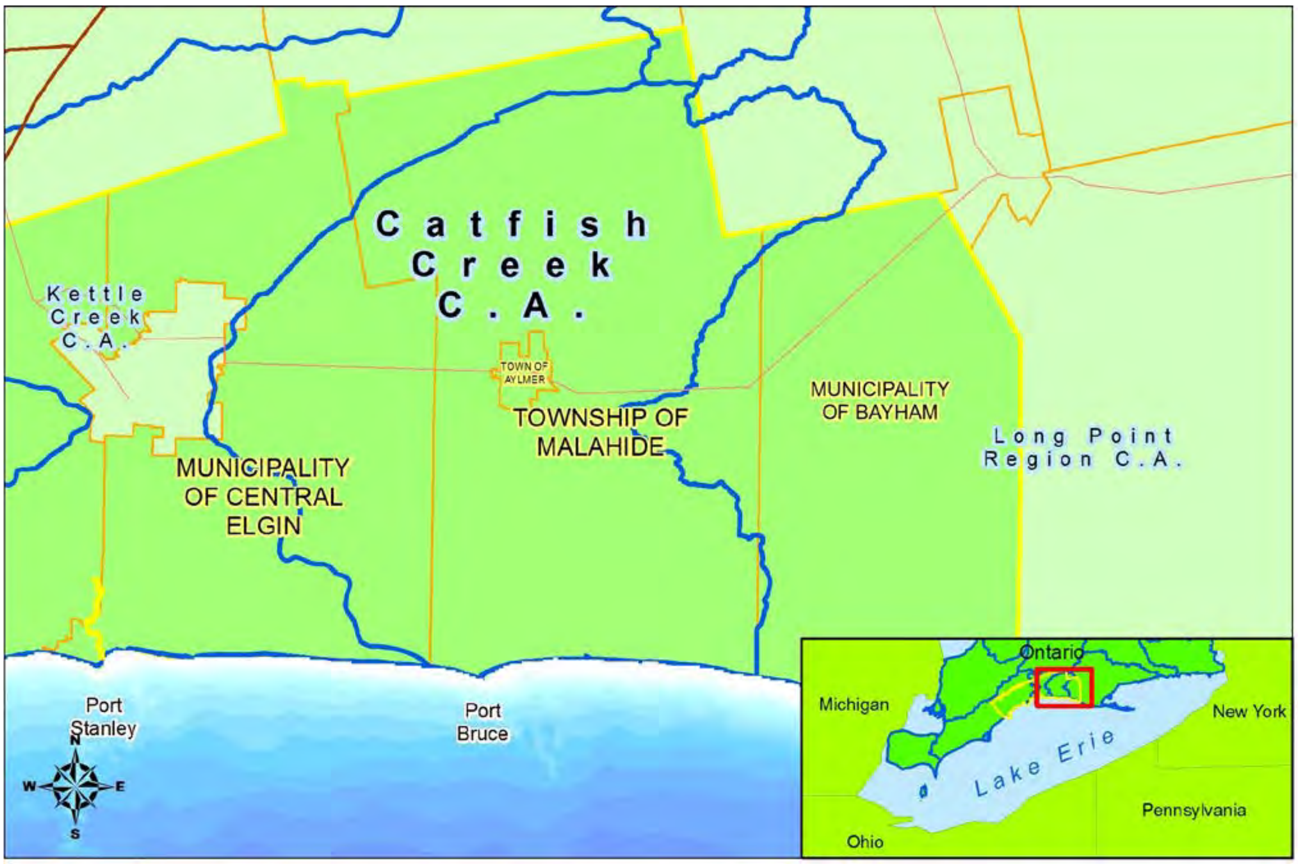

Figure 7.1 Limit of CCCA Watershed and Shoreline within Elgin County

7.1 Introduction

As noted in Section 1.4, the CCCA along with the other three CAs with jurisdiction in Elgin County have jointly developed a consistent shoreline management approach for the north shore of Lake Erie with officials from the County and Municipalities. Several important principles guided the development of this SMP, including integrated coastal zone management, ecosystem based planning and management, along with protection of natural heritage and the conservation of land.

Refer to Section 1.5 for a full description of the principles and objectives used to guide the development of this SMP

Based on these guiding principles and the technical studies completed for this SMP update, a series of objectives were developed to support decision making on the management approach for the coastline. The key objectives include:

- Maintaining physical processes along the coast.
- Protection and restoration of coastal habitat.
- Focusing future development in the Port Communities.
- New development must not create negative impacts of any kind.
- A standardized interpretation of the SMP across Elgin County (to the degree local conditions permit).
- Regular communication on coastal hazards and associated risks to riparian land owners and stakeholders at large.
- Maintain public access to the coastline in perpetuity in the Port Communities.

The majority of the CCCA coastline in Elgin County has been classified as High Bluff, as noted in Figure 7.2. In Port Bruce two additional shoreline reaches were identified to characterize the condition of the west fillet beach, navigation channel, and existing shoreline development. The management approach for these shoreline reaches is described in the following sections of this SMP.

The shoreline management approach for the three reaches that characterize the CCCA coastline is described in the following sections of the SMP.

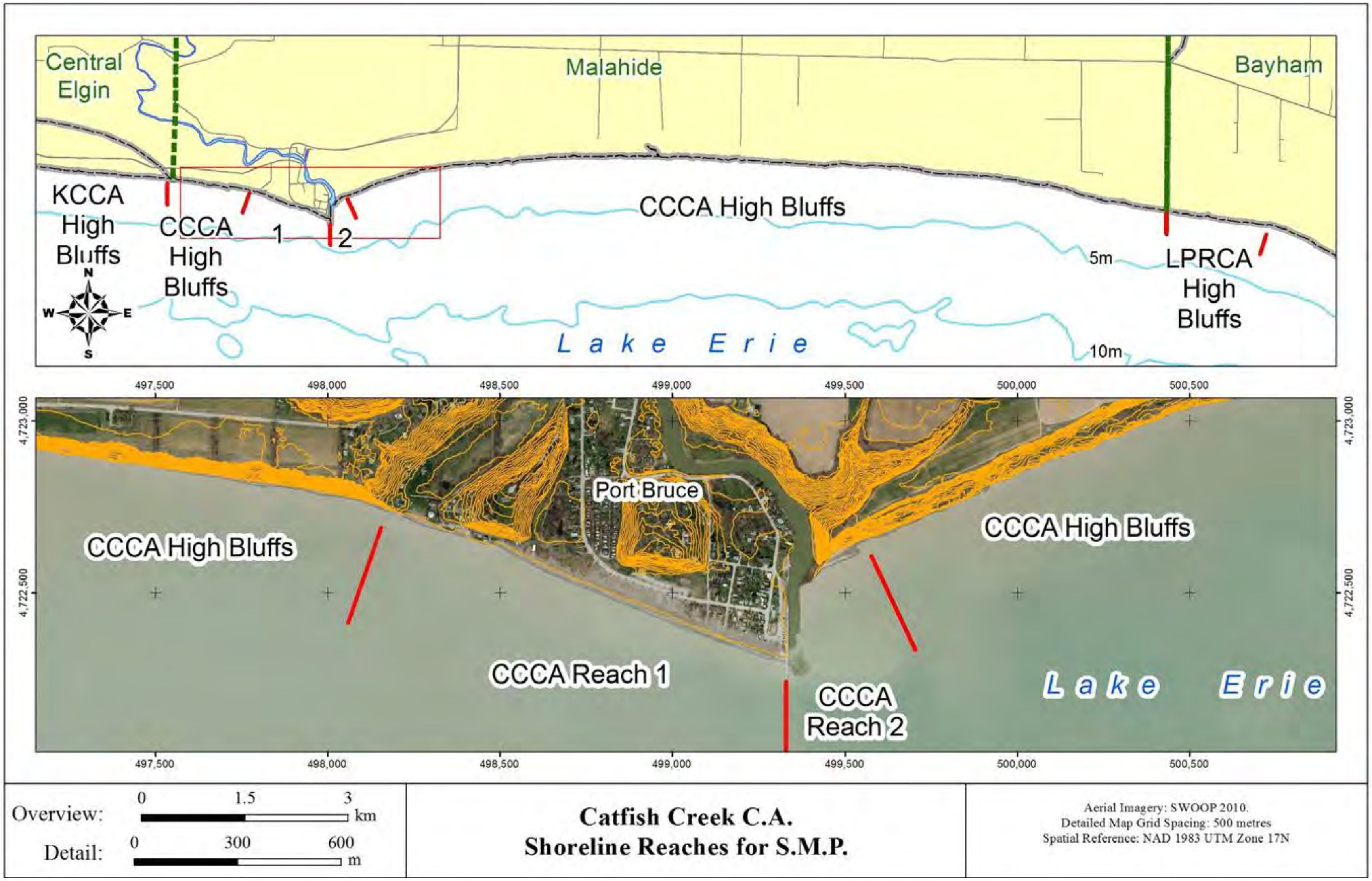

Figure 7.2 CCCA Shoreline Reaches

7.2 CCCA High Bluffs – Managed Retreat

The approach to calculate historical recession rates for the CCCA high bluff shoreline was described in Section 2.4. The erosion rate for the high bluffs west of Port Bruce is 2.2 m/yr, which translates into a horizontal setback of 220 m, measured landward from the stable slope allowance. The stable slope allowance is a horizontal setback equivalent to three times the bluff height and thus varies based on the height of the bluff along the coast. From Port Bruce to the eastern limit of the CA, the erosion rate is 2.3 m/yr. This represents a horizontal erosion setback of 230 m.

Future development should be directed to areas outside of the shoreline hazard, as defined by the erosion hazard limit. Guidance for limited development activities in the regulated area is provided in Table 4.1 of Section 4.1.1.1. Existing buildings that are threatened by slope instability or erosion should be relocated away from these natural hazards. As noted in Figure 7.3, a total of eight primary buildings were identified within the 3:1 stable slope setback, based on the 2010 orthophotographs. These structures are located south of Dexter Line and west of Waneeta Beach Drive.

No development is safe within the 3:1 stable slope setback and as such, owners of such assets (e.g. buildings) should be notified. A new policy could be developed in keeping with the Elgin County Emergency Response Plan and local zoning bylaws that prohibit occupation of such dwellings, particularly those within 10 m of the bluff crest (the Zone of Pending Failure). At any time in the future, the land within this zone and any assets could be completely lost in the next bluff failure. Due to the severity of these hazards, it is advised that all activities be directed to a location further inland, including recreational pursuits, trails, temporary parking, sitting of mobile recreational vehicles, etc. Refer to Figure 7.4 for an example of a residence in close proximity to the eroding bluff crest.

In addition, road infrastructure that exists within the 3:1 stable slope setback is not safe and the County and Municipalities are encouraged to continue their review the transportation network along the coast to ensure safe access to dwellings for residents and emergency response personnel. The mapping from this SMP could be used to assist with long-term planning for the transportation network along the coast and emergency response.

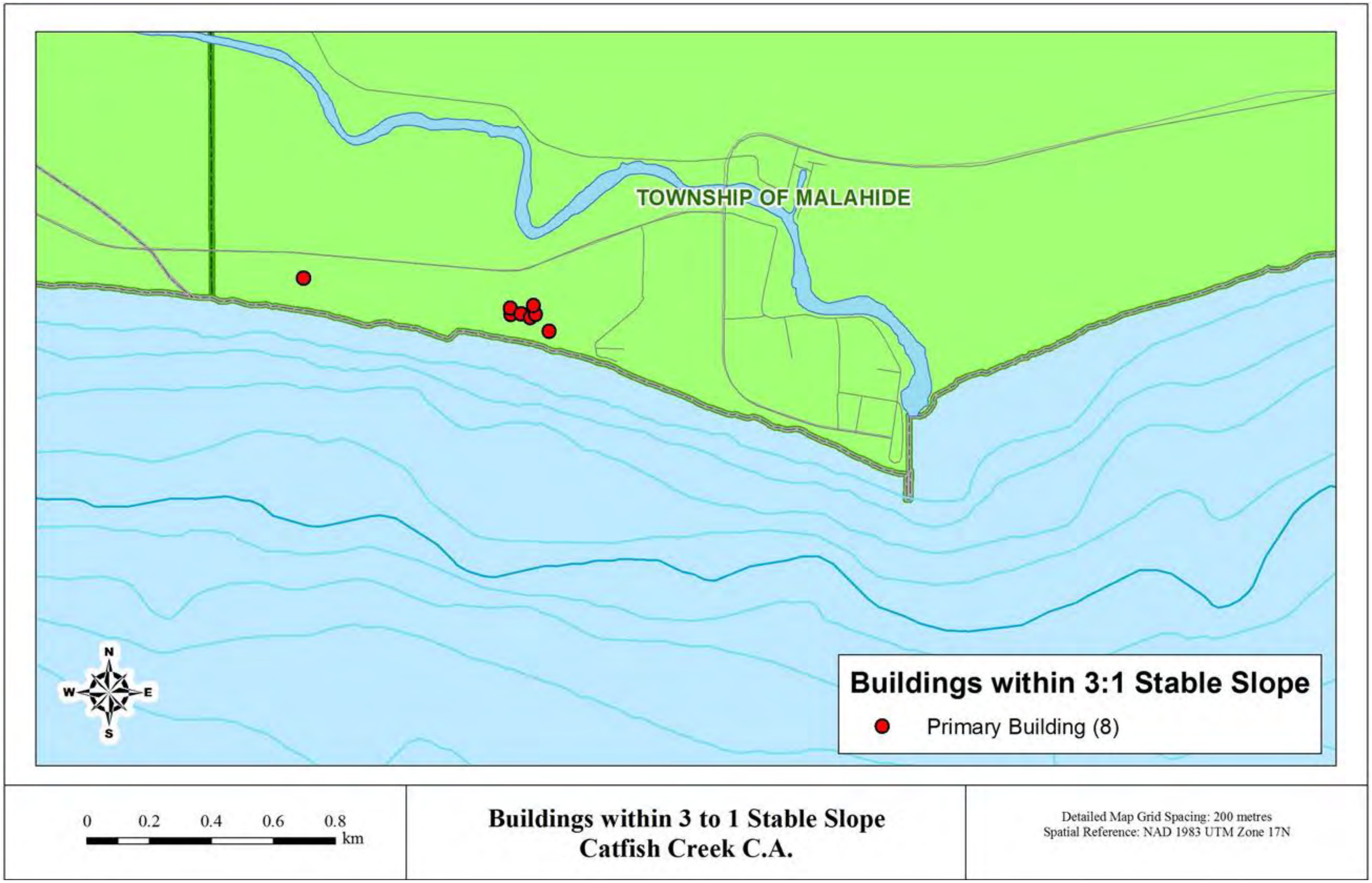

Figure 7.3 Buildings within the 3:1 Stable Slope Setback in CCCA

Figure 7.4 Building with 3:1 Stable Slope Setback

7.3 CCCA Reach 1 – Protect Beach and Promote Public Access

The western fillet beach at Port Bruce has been classified as CCCA Reach 1, as noted in Figure 7.2. This portion of the CCCA Lake Erie cost is approximately 1.2 km in length and includes the sand beach adjacent to the navigation channel, the sandy beach and dunes of Port Bruce Provincial Park, and a small area of residential development with shoreline protection at the western end of the reach.

The shoreline position in the western 200 m of CCCA Reach 1 has been artificially stabilized with a series of private steel sheet pile walls protecting the residential development. Refer to Figure 7.5 for a picture of a typical structure. The eroding bluffs west of Waneeta Beach Road are visible in the background of the photograph. As the shoreline continues to migrate further inland towards Dexter Line, these vertical steel sheet pile walls will be susceptible to flanking erosion and lakebed downcutting, and thus should be monitored on an annual basis.

Figure 7.5 Steel Sheet Pile Wall Protecting Residential Development in CCCA Reach 1

The beaches and dunes in the Provincial Park are protected from development and provide a natural barrier to Imperial Road. Beach goers should be encouraged to access the lake from a series of existing trails to avoid damage to the fragile dune vegetation.

Figure 7.6 Beach and Dunes at Port Bruce Provincial Park

The eastern limit of CCCA Reach 1 features a public beach and access to the western jetty at the rivermouth. The development at the back of the beach is separated with a narrow strip of dune vegetation. Foot traffic should be directed away from this vegetated area, as it provides important flood protection during Lake Erie storms and if the dune was permitted to grow in elevation, it would provide more effective flood protection.

Figure 7.7 Fillet Beach in Port Bruce Adjacent to the Western Jetty

7.4 CCCA Reach 2 – Maintain Flood Conveyance and Sediment Bypassing

The jetties and navigation channel are the predominate feature in CCCA Reach 2. The jetties are a popular fishing destination and represent an important access point to the Lake Erie shoreline. Refer to Figure 7.8. The eastern jetty consists of a single steel sheet pile wall and terminates into the eroding bluff. The position of the bluff toe and riverbank are protected with rip rap. This protection should be inspected at least annually, as its continued existence is critical to maintaining a protected and stable navigation channel. If the protection fails and bluff erosion commences, then the existing steel sheet pile wall will be separated from the shore and the river will have two outflow channels.

Figure 7.8 Western Jetty in Port Bruce

Figure 7.9 Eastern Jetty at Port Bruce and Protection at the Toe of Bluff

A sedimentation study (Riggs, 2012) was recently completed to evaluate historical changes in the river depths and flood conveyance. The study concluded the majority of sediment that accumulates on the river bed is from upstream fluvial sources. Therefore, remedial options focused on solutions that would increase the flood conveyance, minimize sedimentation and not negatively impact ice jamming. The recommended solution was continuation of river dredging and monitoring of future sedimentation patterns.

As noted in the Riggs (2012) sedimentation study, the majority of the littoral sediment is estimated to bypass Port Bruce and continue along the coast to Port Burwell. Maintaining high rates of sediment bypassing of the jettied navigation channel is an important objective of the SMP, as sand and gravel deposits are important for beach building, maintaining lake bottom habitat, and reducing long-term erosion rates at the bluff toe. Any sand and gravel dredged from the navigation channel should be re-deposited in the littoral system, such as nearshore zone east of Port Bruce. In addition, any future modifications to the jettied navigation channel should be carefully evaluated to ensure there are no negative impacts on sediment bypassing.

7.5 Mapping of Hazardous Lands

The hazardous lands for the CCCA Lake Erie shoreline are mapped on Sheets 60 to 74, and are provided in Appendix F. The erosion, flooding, and dynamic beach setbacks are depicted on the maps, collectively defining the hazardous lands along the Lake Erie shoreline for the CCCA. The flooding hazard is defined by the 100 year instantaneous lake level (175.6 m, CGVD'28) plus a 15 m horizontal setback. The dynamic beach setback includes an additional 30 m, measured landward, from the flood hazard limit. Sheet 61 marks the transition from the High Bluffs to CCCA Reach 1 and is provided in Figure 7.10. There are a number of buildings within the Stable Slope Allowance on Sheet 61 as the high bluff transitions to the fillet beach. For the eastern half of Sheet 61, the hazardous lands are defined the dynamic beach standard.

The majority of the lands east of Port Bruce are rural and used predominantly for agriculture. Refer to Figure 7.11 for a typical rural Sheet in the CCCA watershed. The road network is also largely oriented in a north-south direction, making the managed retreat approach easier to implement than the other CA watersheds in Elgin County.

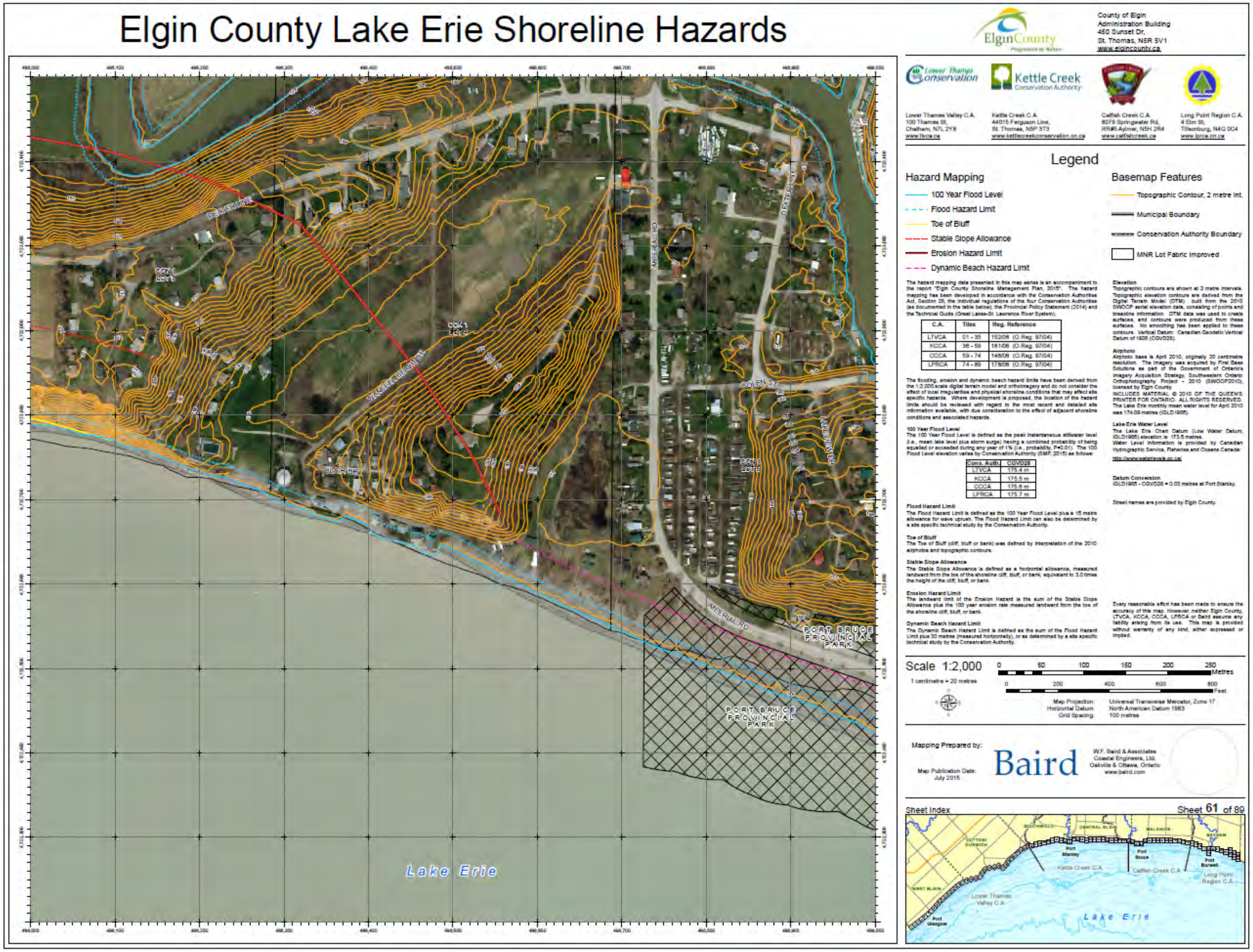

Figure 7.10 Sheet 61 at Port Bruce

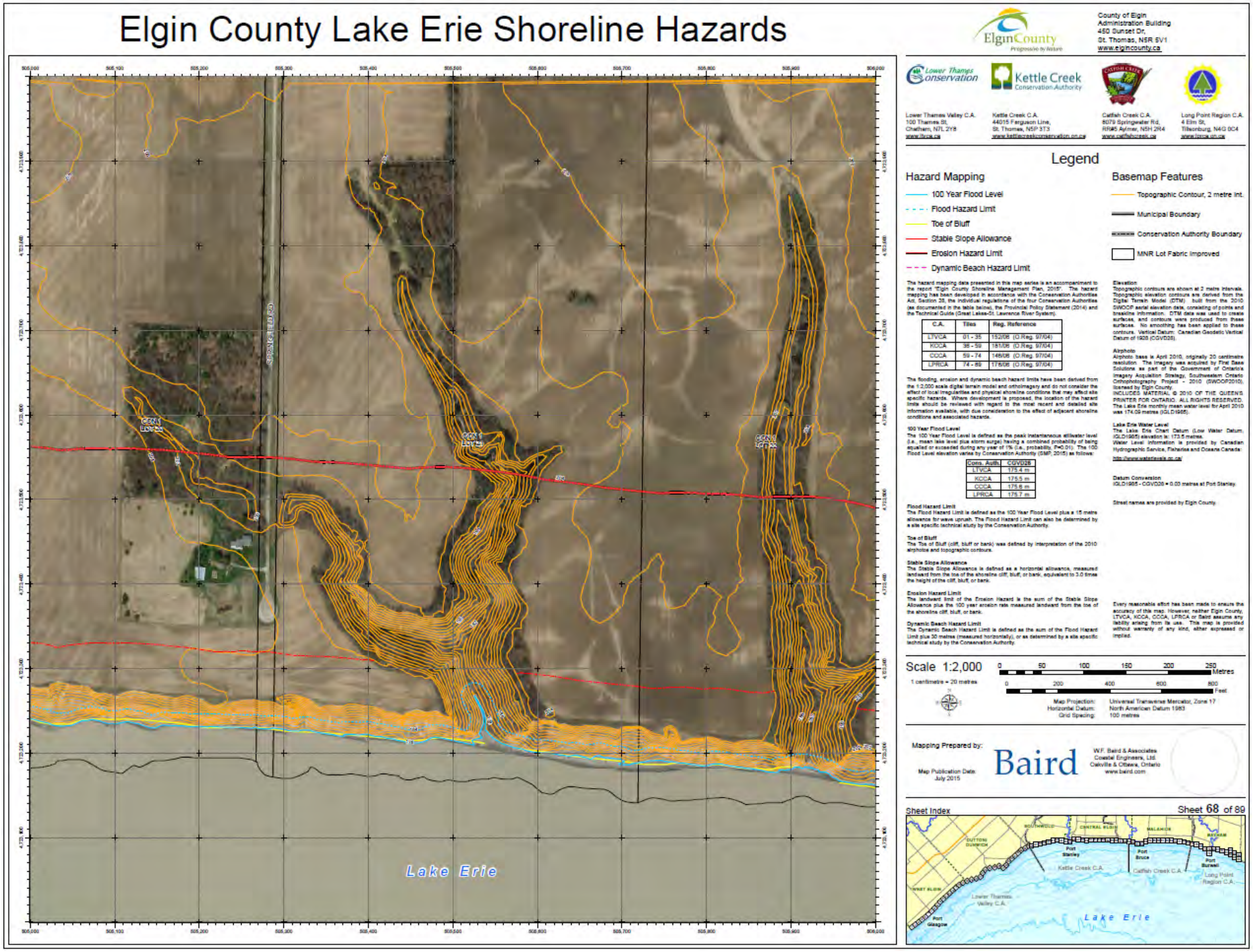

Figure 7.11 Sheet 68 East of Port Bruce

8.0 LONG POINT REGION CONSERVATION AUTHORITY SHORELINE MANAGEMENT PLAN

The previous SMP for the LPRCA (Philpott, 1989) provided management direction for new development along the coast of the CA for more than 25 years. This updated SMP builds on the historical information in the old plan and the new technical analysis completed for this investigation. Figure 8.1 maps the portion of the LPRCA watershed and coastline that fall within Elgin County. The majority of the LPRCA watershed is located to the east within other county and municipal jurisdictions.

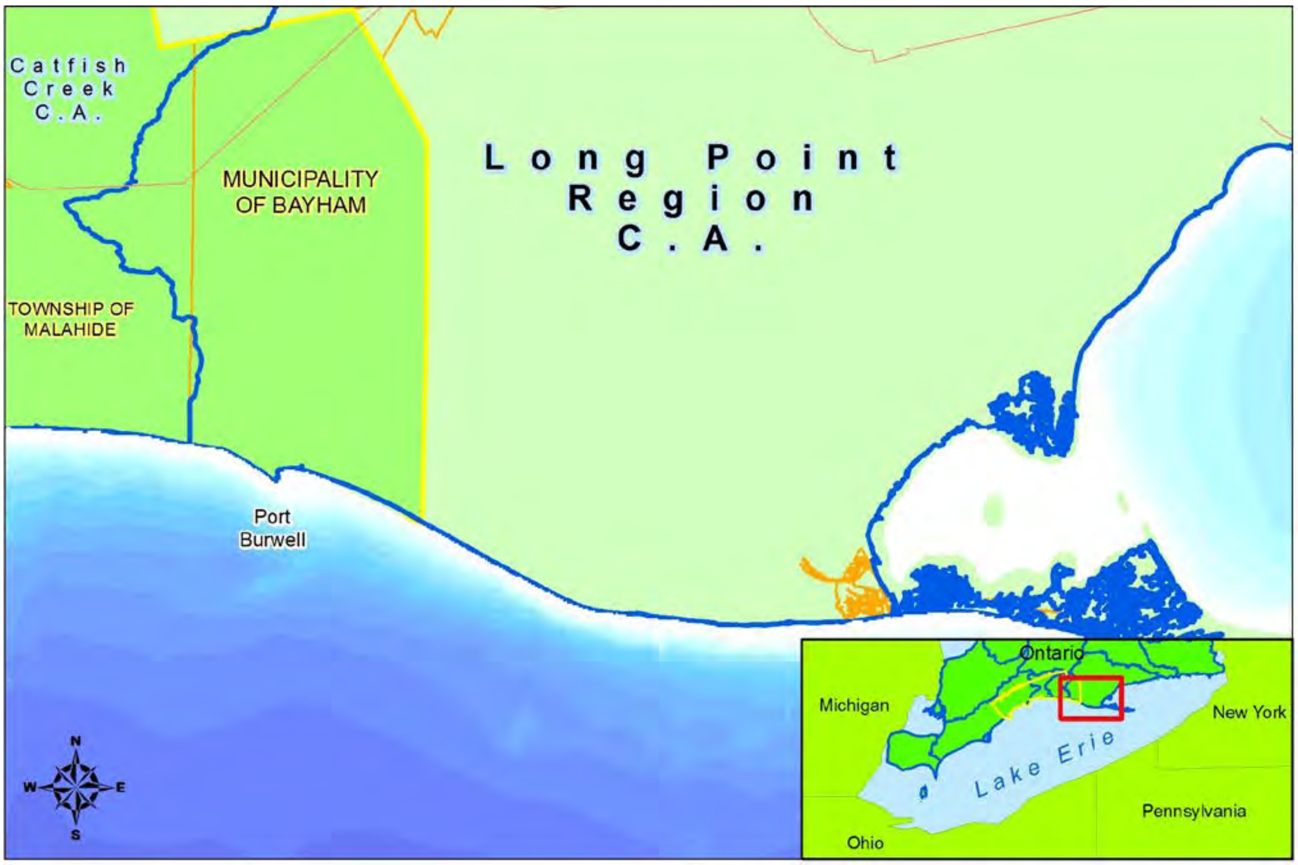

Figure 8.1 Limit of LPRCA Watershed and Shoreline within Elgin County

8.1 Introduction

As noted in Section 1.4, the LPRCA along with the other three CAs with jurisdiction in Elgin County have jointly developed a consistent shoreline management approach for the north shore of Lake Erie with officials from the County and Municipalities. Several important principles guided the development of this SMP, including integrated coastal zone management, ecosystem based planning and management, along with protection of natural heritage and the conservation of land.

Refer to Section 1.5 for a full description of the principles and objectives used to guide the development of this SMP.

Based on these guiding principles and the technical studies completed for this SMP update, a series of objectives were developed to support decision making on the management approach for the coastline. The key objectives include:

- Maintaining physical processes along the coast.
- Protection and restoration of coastal habitat.
- Focusing future development in the Port Communities.
- New development must not create negative impacts of any kind.
- A standardized interpretation of the SMP across Elgin County (to the degree local conditions permit).
- Regular communication on coastal hazards and associated risks to riparian land owners and stakeholders at large.
- Maintain public access to the coastline in perpetuity in the Port Communities.

The majority of the LPRCA coastline in Elgin County has been classified as High Bluff, as noted in Figure 8.2. In Port Burwell three additional shoreline reaches were identified to characterize the condition of the west fillet beach, navigation channel, and existing shoreline development to the east of the navigation channel. The management approach for these shoreline reaches is described in the following sections of this SMP.

The shoreline management approach for the four reaches that characterize the LPRCA coastline is described in the following sections of the SMP.

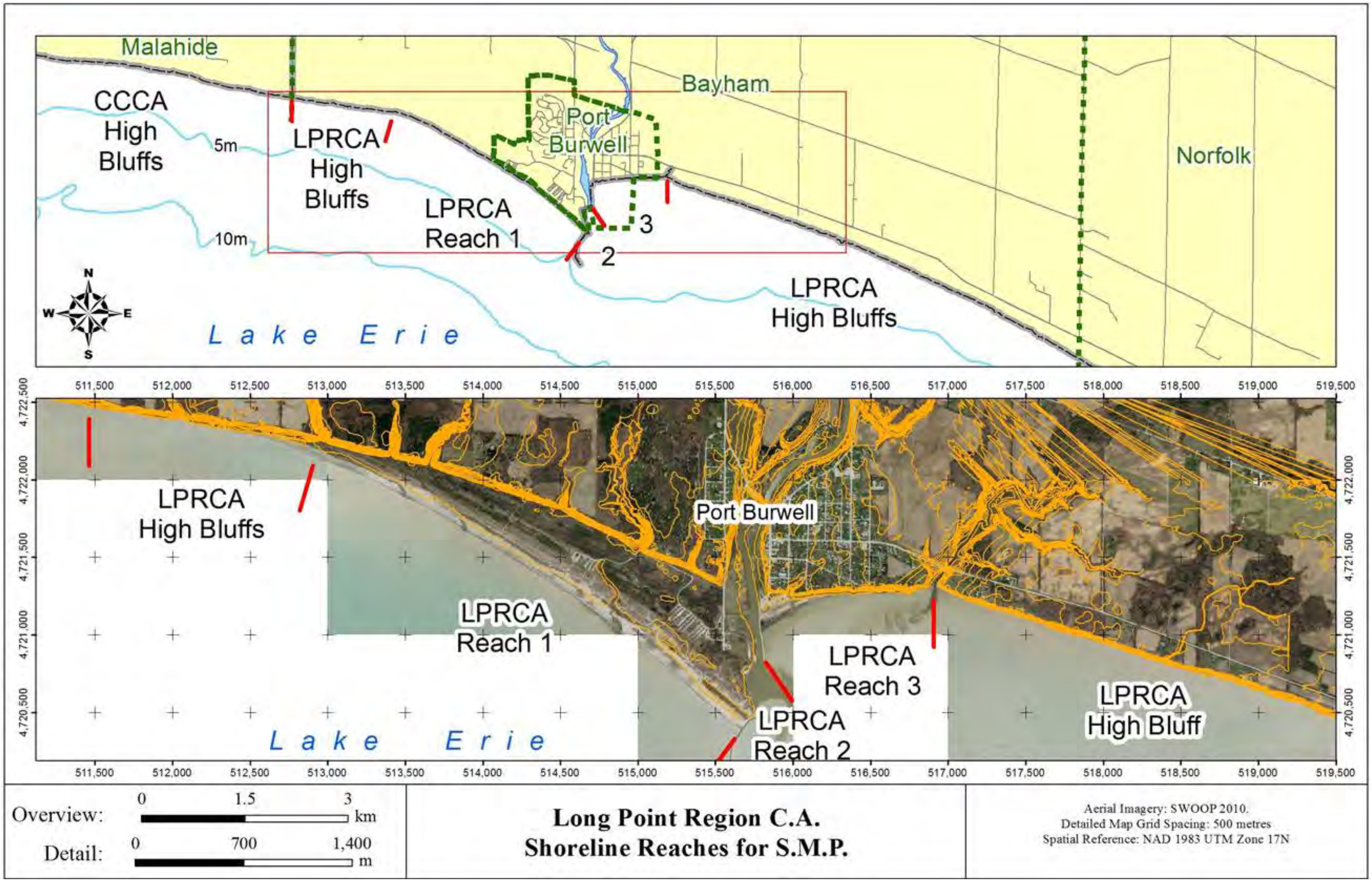

Figure 8.2 Shoreline Reaches in LPRCA

8.2 LPRCA High Bluffs – Managed Retreat

The approach to calculate historical recession rates for the LPRCA high bluff shoreline was described in Section 2.4. The erosion rate for the high bluffs west of Port Burwell is 2.3 m/yr, which translates into a horizontal setback of 230 m, measured landward from the stable slope allowance. The stable slope allowance is a horizontal setback equivalent to three times the bluff height and thus varies based on the height of the bluff along the coast. From Port Burwell to the eastern limit of the CA, the erosion rate is 4.8 m/yr. This represents a horizontal erosion setback of 480 m.

Future development should be directed to areas outside of the shoreline hazard, as defined by the erosion hazard limit. Guidance for limited development activities in the regulated area is provided in Table 4.1 of Section 4.1.1.1. Existing buildings that are threatened by slope instability or erosion should be relocated away from these natural hazards. As noted in Figure 8.3, a total of six primary buildings and 25 secondary buildings were identified with the 3:1 stable slope setback, based on the 2010 orthophotographs. These structures are located east of Port Burwell and south of Lake Shore Line.

No development is safe within the 3:1 stable slope setback and as such, owners of such assets (e.g. buildings) should be notified. A new policy could be developed in keeping with the Elgin County Emergency Response Plan and local zoning bylaws that prohibit occupation of such dwellings, particularly those within 10 m of the bluff crest (the Zone of Pending Failure). At any time in the future, the land within this zone and any assets could be completely lost in the next bluff failure. Due to the severity of these hazards, it is advised that all activities be directed to a location further inland, including recreational pursuits, trails, temporary parking, sitting of mobile recreational vehicles, etc.

In addition, road infrastructure that exists within the 3:1 stable slope setback is not safe and the County and Municipalities are encouraged to continue their review the transportation network along the coast to ensure safe access to dwellings for residents and emergency response personnel. The mapping from this SMP could be used to assist with long-term planning for the transportation network along the coast and emergency response. Refer to Figure 8.4 for a picture of Lake Shore Line, which has been closed due to the erosion threat.

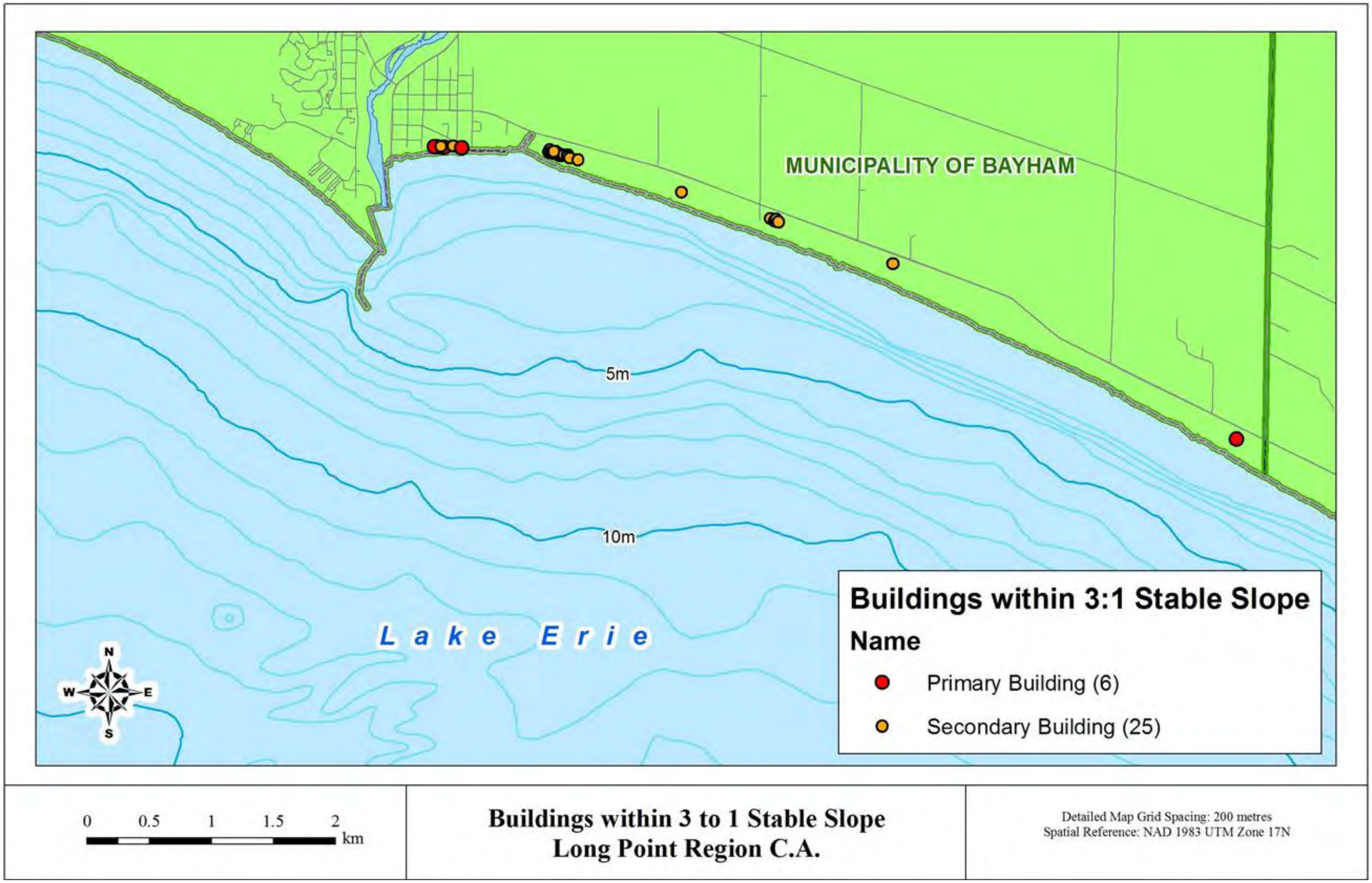

Figure 8.3 Buildings within the 3:1 Stable Slope Allowance (Zone of Higher Risk)

Figure 8.5 Section of Lake Shore Line Closed Due to the Erosion Hazard

8.3 LPRCA Reach 1 – Protect Beaches and Promote Public Access

LPRCA Reach 1 is approximately 3 km in length and represents one of the largest fillet beaches along the Canadian shores of the Great Lakes. The estimated volume of sand and gravel trapped in the fillet beach is 13 million m^3. Without the construction of the jettied entrance at the mouth of Big Otter Creek, this sediment would have been transported to the east and ultimately deposited in the Long Point Sand Spit.

The majority of Reach 1 falls under the jurisdiction of Port Burwell Provincial Park. The westerly most 800 m are outside of the park boundary and thus future management decisions will be guided by this plan. For this portion of Reach 1, no development will be permitted within the lands classified by the dynamic beach standard. The beach and dune habitat should be protected for passive recreational uses (e.g. walking and swimming) and for the species that rely on this unique ecosystem.

Access to the beach within the Provincial Park is already controlled via identified access routes. Refer to Figure 8.5. Directing the beach goers to these dedicated access trials to reach the water's edge eliminates foot traffic on the sensitive dune species.

Provided the jettied entrance to Big Otter Creek is maintained, the western fillet beach at Port Burwell will remain stable indefinitely. By extension, the tablelands landward of the park boundary (to the north) are protected from coastal hazards. Therefore, future growth in the Municipality of Bayham should be directed to such areas that are not threatened by shoreline erosion and flooding, and away from the eroding high bluffs. This approach is consistent with the Elgin County Official Plan.

Figure 8.6 Controlled Beach Access within Port Burwell Provincial Park

8.4 LPRCA Reach 2 – Maintain Flood Conveyance and Sediment Bypassing

LPRCA Reach 2 consists of the engineering structures and navigation channel at the mouth of Big Otter Creek. The western jetty is approximately 800 m longer than the eastern jetty, which creates a sediment trap for sand and gravel moving east to west along the shoreline. In addition, it is possible that fine sediments transported down the river are deposited in this region. A picture of the western armour stone jetty is provided in Figure 8.7.

Figure 8.7 Armour Stone Jetty Extension (west jetty) at Port Burwell

The channel depths in the Big Otter Creek and near the tip of the eastern jetty should be regularly monitored to ensure the river is capable of conveying the spring floods and other high flow events to minimize the potential for localized flooding.

All future maintenance activities for the engineering structures in LPRCA Reach 2 should consider the potential negative impacts of trapping additional littoral sediment in the western fillet beach. For example, any additional sand trapped in the beaches of the Provincial Park will be starving the beaches at the Long Point sand spit. Any proposed modifications of the engineering structures should be accompanied by a comprehensive study to restore the natural rate of sediment bypassing at Port Burwell.

8.5 LPRCA Reach 3 – Hold the Line

LPRCA Reach 3 is approximately 1.2 km in length and consists of the smaller eastern fillet beach at Port Burwell and dense residential development located landward of the bluff crest. Refer to Figure 8.8. With the present lake level conditions in 2014/2015 (e.g. average), the fillet beach is approximately 600 m in length. However, as seen in Figure 8.8, the beach has a very flat slope and overall features a low elevation profile (especially when compared to western fillet beach in the Provincial Park). When high water levels return to Lake Erie, a significant portion of the sand beach will be submerged, thus reducing the size of the dry beach.

Figure 8.8 Eastern Fillet Beach at Port Burwell

The conditions at the back of the beach and adjacent parking lot are presented in Figure 8.9. Similar to the water's edge, the area is very flat and low lying. It also appears the beach is raked or manicured in some way, which would explain the lack of any native dune species. If the beach was maintained in a natural state and access was controlled/limited to select walkways, natural dune vegetation would colonize the back of the beach, encourage the deposition of sediment and raise the overall volume of sand stored at the back of the beach. This in turn would increase the flood and erosion protection provided by the beach, and enhance local habitat. A future restoration project should be pursued by all stakeholders.

Figure 8.9 Transition from Eastern Fillet Beach to Parking Lot

The remainder of LPRCA Reach 3 is protected by a long armour stone revetment. A picture of a typical section is provided in Figure 8.10. The ownership of this structure should be ascertained and a regular maintenance program should be developed. It provides critical erosion protection to the high density development located landward of the bluff crest. However, as documented in Section 4.4, these types of shore parallel structures do not stop lakebed downcutting in front of the structure and thus they are susceptible to toe failures.

Figure 8.10 Armour Stone Revetment at the Foot of Pitt Street

Provided the shoreline protection in Reach 3 is maintained, future lakefront growth in Bayham should be focused landward of the shoreline beyond the limits of the regulated lands. Connectivity of existing and new development to the lakeshore via a multi-use trail network is encouraged.

Given the age of the existing revetment in Reach 3 and its role in stabilizing an otherwise eroding shoreline, future development adjacent to this structure may require a detailed engineering investigation to address slope stability and the remaining design life of the revetment.

8.6 Mapping for Hazardous Lands

The hazardous lands for the LPRCA Lake Erie shoreline are mapped on Sheets 74 to 89, and are provided in Appendix G. The erosion, flooding and dynamic beach setbacks are depicted on the maps, collectively defining the hazardous lands along the Lake Erie shoreline for the LPRCA. The flooding hazard is defined by the 100 year instantaneous lake level (175.7 m, CGVD'28) plus a 15 m horizontal setback. The dynamic beach setback includes an additional 30 m, measured landward, from the flood hazard limit.

Sheet 80 includes the transition from LPRCA Reach 3 to the High Bluffs at the mouth of Little Otter Creek. There is uncertainty about the future evolution of the shoreline as it switches between an armoured shoreline to an eroding coastal bluff. Predicting the future evolution of the shoreline in this region is beyond the scope of this SMP. As such, future proponents of development applications in this region of the CA may be required to complete a special site specific investigation as outlined by the CA officials. Refer to Sheet 80 for the detailed mapping.

A large number of trailer homes are located within the 3:1 Stable Slope setback at the ErieVu Trailer Park just east of Port Burwell, as seen in Figure 8.12, along with a private road. The owners of this park should be notified of the serious nature of the erosion risks associated with bluff recession.

The majority of the lands east of Port Burwell are rural and used predominantly for agriculture. Lake Shore Line is already fragmented in several locations due to the retreating bluffs. Soon the north-south road network will be the only access points to the shoreline. The implications for the local transportation network and emergency access should be evaluated.

Figure 8.11 Sheet 80 East of the Big Otter Creek in Port Burwell

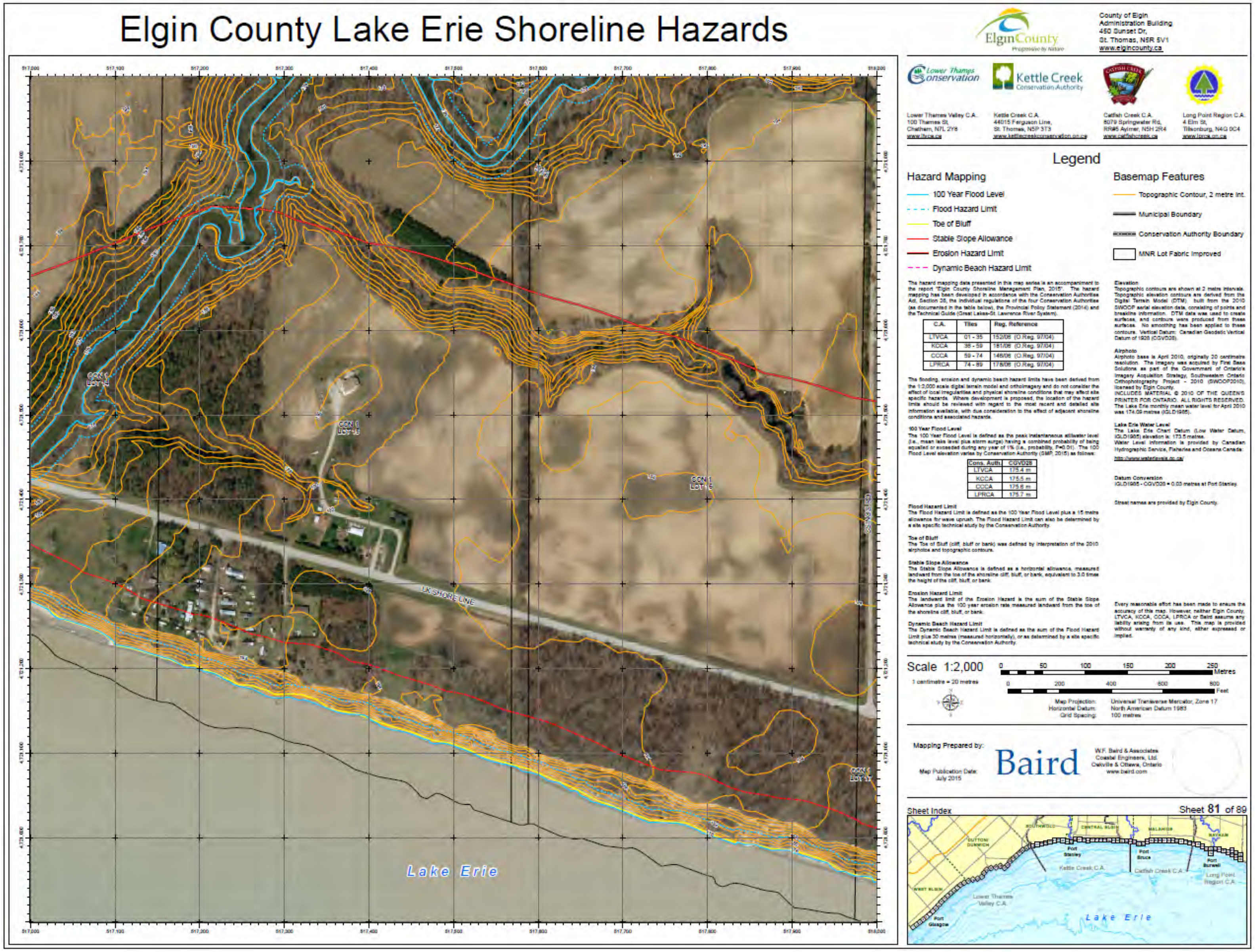

Figure 8.12 Sheet 81 East of the Little Otter Creek in Port Burwell

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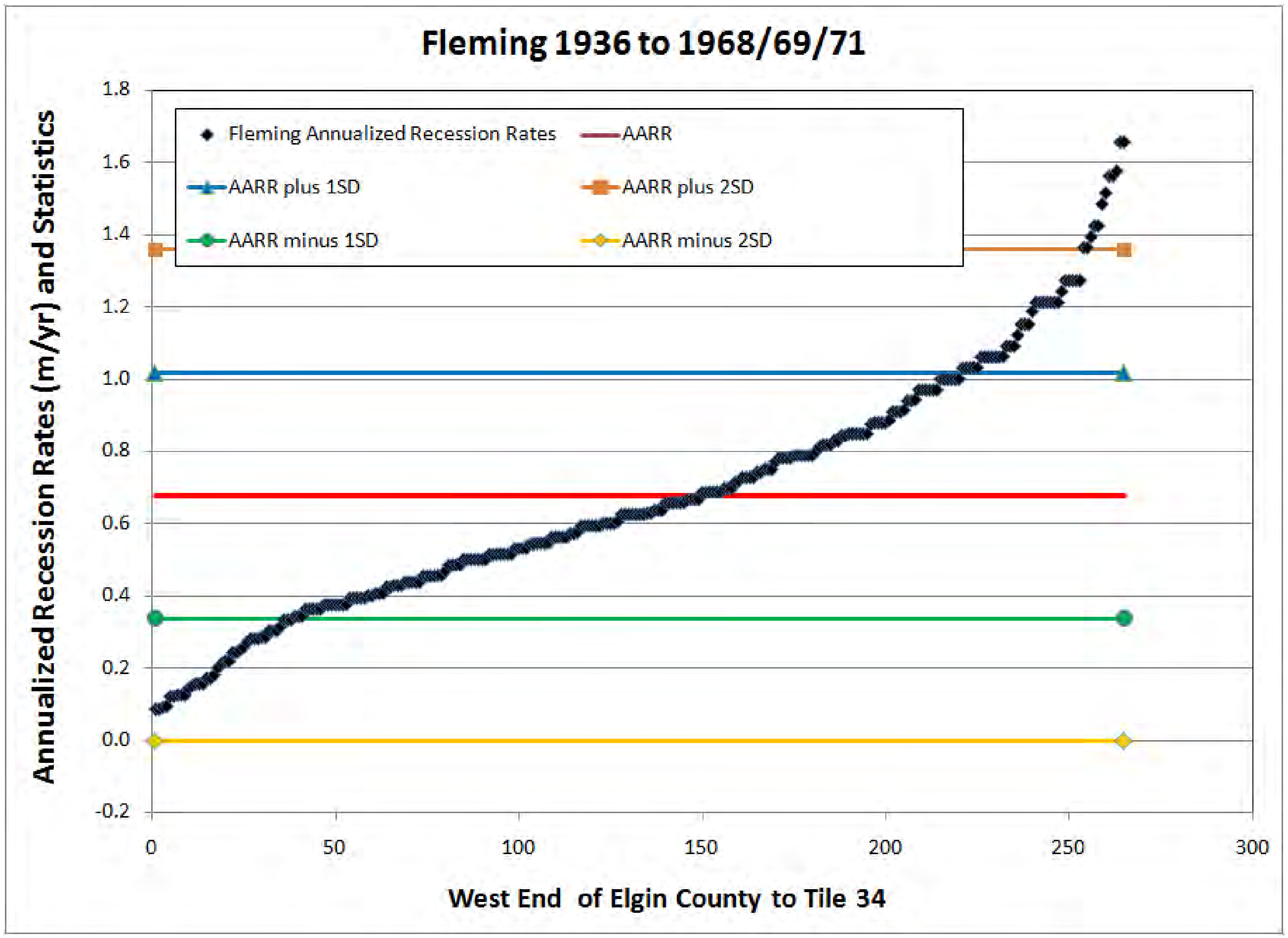
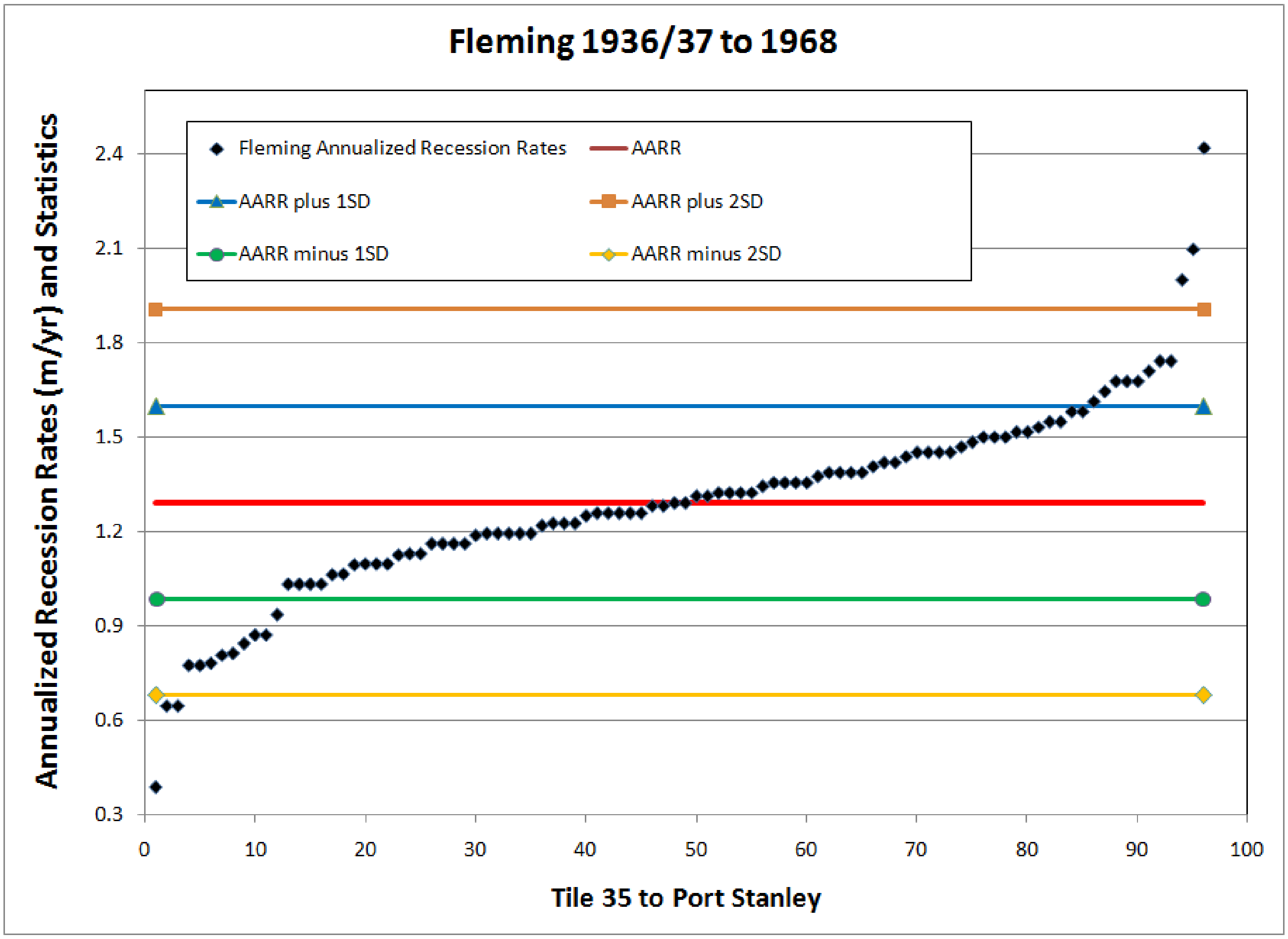
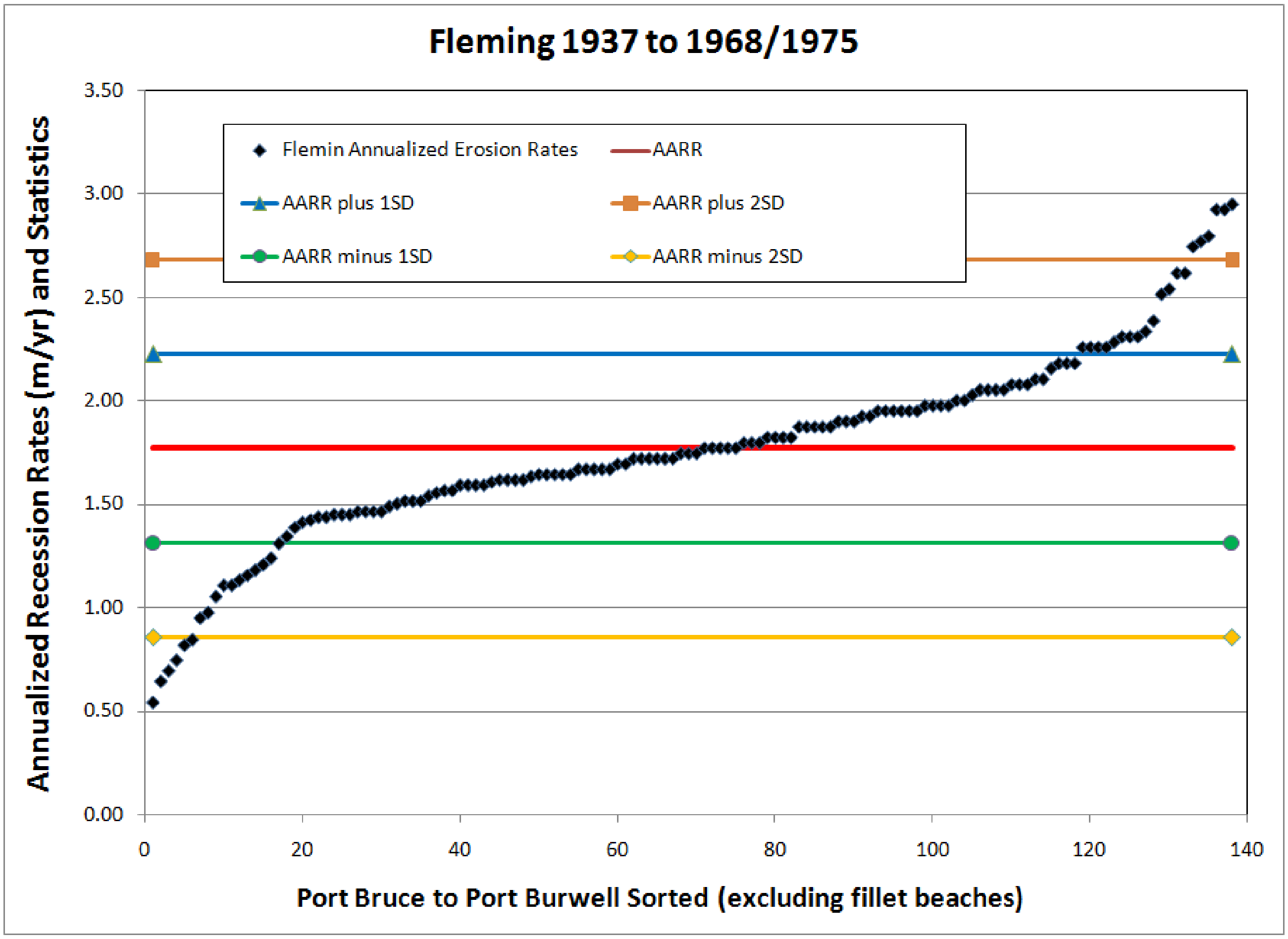
APPENDIX A

STATISTICAL ANALYSIS OF FLEMING (1983) RECESSION DATA

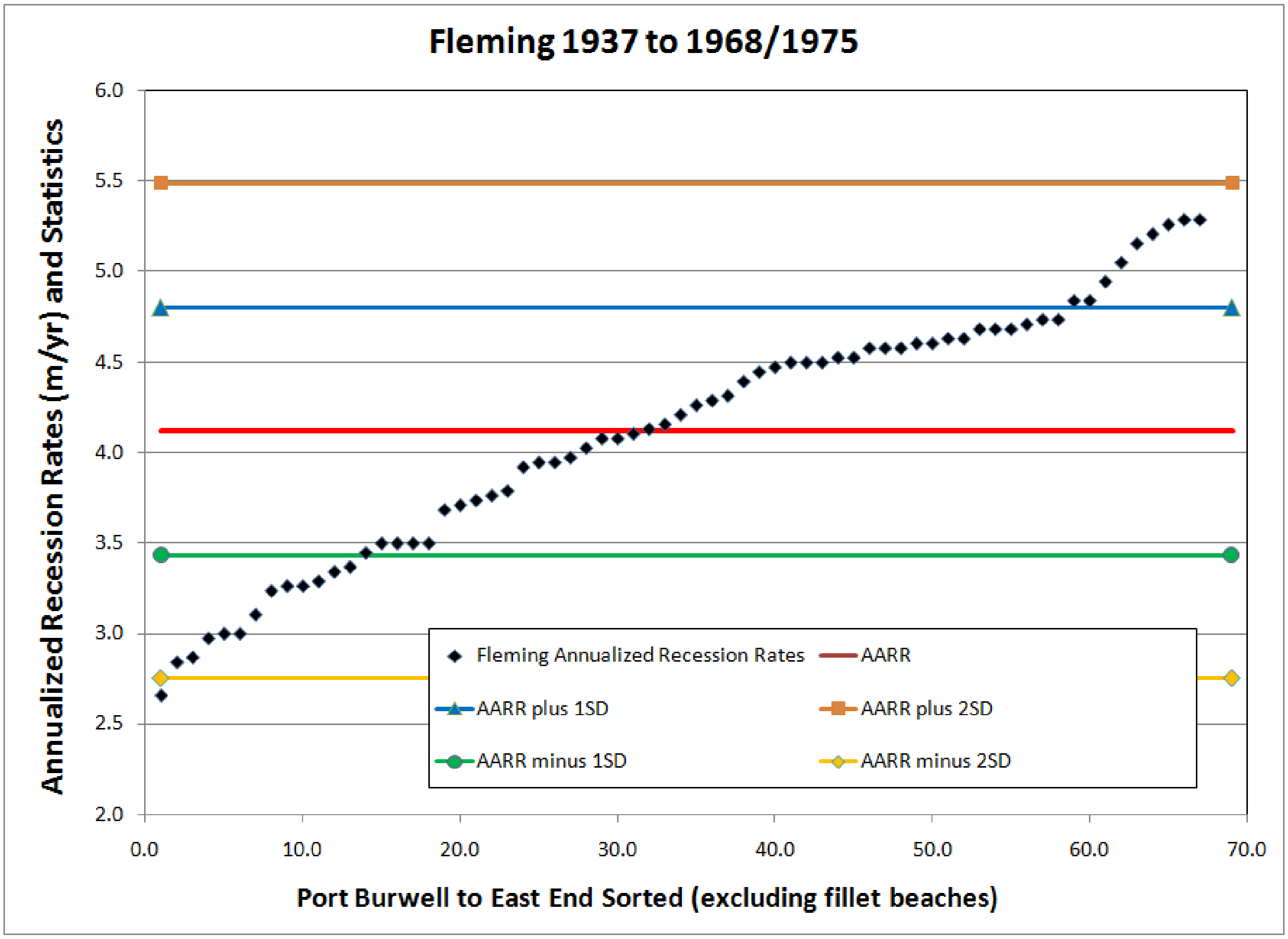

Fleming 1936 to 1968/69/71
Fleming Annualized Recession Rates
AARR
AARR plus 1SD
AARR plus 2SD
AARR minus 1SD
AARR minus 2SD
Annualized Recession Rates (m/yr) and Statistics
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
50
100
150
200
250
300
West End of Elgin County to Tile 34



Fleming 1936/37 to 1968
Fleming Annualized Recession Rates
AARR
AARR plus 1SD
AARR plus 2SD
AARR minus 1SD
AARR minus 2SD
Annualized Recession Rates (m/yr) and Statistics
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
0
10
20
30
40
50
60
70
80
90
100
Tile 35 to Port Stanley



Fleming 1937 to 1968/1975
Annualized Recession Rates (m/yr) and Statistics
Port Bruce to Port Burwell Sorted (excluding fillet beaches)
Flemin Annualized Erosion Rates
AARR
AARR plus 1SD
AARR plus 2SD
AARR minus 1SD
AARR minus 2SD
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
20
40
60
80
100
120
140


Fleming 1937 to 1968/1975
Annualized Recession Rates (m/yr) and Statistics
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Port Burwell to East End Sorted (excluding fillet beaches)
Fleming Annualized Recession Rates
AARR
AARR plus 1SD
AARR plus 2SD
AARR minus 1SD
AARR minus 2SD

APPENDIX B

HYDSTAT Model Description

The model HYDSTAT was used to complete the joint probability analysis for the flooding evaluation study. HYDSTAT is a well recognized model that has been used extensively around the Great Lakes for other flood level and water related hazard studies (FEMA, 1988; OMNRF 1989). Two other models were considered (JOIN-SEA and HEC-SSP) but were not selected for use in this study.

HYDSTAT uses eight statistical distributions to fit the provided data: Normal, Log-Normal, Gumbel, Log-Gumbel, Pearson Type III, Log-Pearson Type III (LP3), 3-parameter Log-Normal and Generalized Extreme Value (GEV). For multi-variate analyses, the user inputs sample populations of each independent variable (in this case there are two independent variables, water levels, X and surge, Y) and HYDSTAT fits the eight distributions to each dataset using the method of moments. The least-squares standard error is calculated for each distribution and the lowest value is used to select the best-fitting distribution for each independent variable. HYDSTAT then uses the convolution formula and numerical integration to calculate discrete values of Z (a multi-variate parameter) from the multiple integral formed by the product of the independent variable's probability distributions (described below in Equation 2) and fits a joint probability distribution to the new variable, Z.

When water levels and surge are considered, the multi-variate parameter, Z, is related to the independent variables (water level, X and surge, Y) as follows:

$$Z_{ij} = C_1 X_i^{EX_1} + C_2 Y_j^{EX_2} + \text{Constant} \quad (1)$$

where:
- X_i is the i[th] value of the first random variable (water level)
- Y_j is the j[th] value of the second random variable (surge)
- EX_1 is the exponent of variable 1 (water level)
- EX_2 is the exponent of variable 2 (surge)
- C_1 is the coefficient of variable 1 (water level)
- C_2 is the coefficient of variable 2 (surge)
- Constant is a constant value

In this case, the coefficients and exponents of both variables are equal to 1.0 and the constant value is equal to zero. If X and Y have probability distribution P(X) and P(Y) and are related as in Equation 1, then it follows that:

$$P(Z) = \iint_R p(x).p(y).dydx \quad (2)$$

This integral can be evaluated using the convolution formula to:

$$P(Z) = \int_X p(x) . p(z-x) dx \quad (3)$$

And for discrete variables, the equation can be expressed as:

$$P(Z) = \sum P(X) . P \ (Z-X) \quad (4)$$

HYDSTAT uses discretization (Equation 3) to complete integration of the convolution integral by numerical approximations to create a new multi-variate population, Z. Once the multi-variate dataset is created, the eight distributions are then fitted to the combined dataset and the chi-square and least-squares standard error are calculated for each distribution.

In this project, the GEV distribution was selected to determine the joint probability return periods (2-, 5-, 10-, 100-, and 500-year) of water level and surge since it has been found to be a superior distribution (Onoz and Bayazit, 1994). If the GEV distribution could not be fit to the data (in some cases the shape parameter was found to be equal to zero), the LP3 distribution was selected for the multi-variate analysis. The LP3 was also used in the flood levels and water related hazards study completed by OMNRF (1989). The methodology is described in detail in Section 5.0 using the St. Louis and Douglas Study Area on Lake Superior as an example.

APPENDIX C

ENGAGEMENT FOR SMP DEVELOPMENT

ENGAGEMENT FOR THE SMP DEVELOPMENT

Appendix C summarizes the various advisory committees that guided the development of this SMP and the stakeholder feedback received during the public open houses in August 2014.

Advisory Committees

The following committees were established to assist with management and review of the Elgin County SMP.

Steering Committee

The Steering committee provided high level oversight throughout the development of the SMP. The committee members included:

- Don Pearson, General Manager LTVCA
- Elizabeth VanHooren, General Manager KCCA
- Bill Walters, KCCA Vice Chair
- Bill Mackie, KCCA Board of Directors
- Kim Smale, General Manager CCCA
- Sally Martyn, CCCA Chair
- Cliff Evanitski, General Manager LPRCA
- Ron Sackrider, LPRCA Board of Directors
- Dave Beres, LPRCA Board of Directors

Technical Advisory Committee

The Technical Advisory Committee consisted of representatives from Elgin County, the municipalities and the four CAs. Regular meetings were convened to provide information, review the progress of the technical studies, discuss management options for the coastline, and review critical deliverables such as the Hazard Mapping and draft SMP. The members of the Technical Advisory Committee include:

- Valerie Towsley, Resource Technician LTVCA
- Jason Wintermute, Water Management Supervisor/GIS Technician LTVCA
- Joe Gordon, Director of Operations KCCA
- Tony Difazio, Resource Planning Coordinator CCCA

- Ben Hodi, Water Resource Analyst LPRCA
- Jim McCoomb, Senior Planner Municipality of Central Elgin
- Don Leitch, CAO Municipality of Central Elgin
- Brent Clutterbuck, Drainage Superintendent Municipality of Dutton Dunwich, Township of Southwold
- Heather James, Planner Municipality of West Elgin, Dutton Dunwich and Township of Southwold
- Steve Evans, Planner Elgin County
- Eugenio DiMeo, Director of Municipal Services, Township of Malahide
- Tyson Edwards, GIS Technician, Township of Malahide
- Margaret Underhill, Planning Coordinator/Deputy Clerk, Municipality of Bayham
- Amanda McCloskey, Ministry of Natural Resources
- Kyle Stanley, Ministry of Natural Resources and Forestry
- Eric Cleland, Ministry of Natural Resources and Forestry
- Richard Visser, Ministry of Natural Resources and Forestry

Emergency Responders

Following the public meetings in August 2014, two meetings were held with emergency responders and building officials from Elgin County, including local fire chiefs and building inspectors, to discuss hazard management in Elgin County and the safe delivery of emergency services. At the first meeting the emergency responders were updated on the technical studies, including the new hazard mapping and the SMP. Opportunities to leverage the hazard mapping were discussed, such as providing the erosion hazard mapping to the fire departments for pre-planning future operations. Then, with the updated information the fire department would be informed of potential risks associated with responding to an emergency on hazardous lands.

The second topic of discussion was the existing protocol for buildings and other infrastructure located in close proximity to the bluff crest and at risk during the next bluff failure. In many cases, these buildings were not constructed on the bluff edge but rather the continuous recession of the shoreline has brought the bluff edge to the buildings. Refer to Figure C.1, where the 2010 contours (yellow lines) and top of bank (solid red line) are overlaid on the 1978 aerial photograph at the Erie-Vu Campground.

In 1978 the Province of Ontario didn't have a policy for development on hazardous lands, nor did the Conservation Authority have a mandate to evaluate development applications on such lands. So, at the time there was no mechanism to inform the managers of this campground of the hazards associated with development so close to the bluff crest. Since 1978 the bluff crest has retreated approximately 100 m and there has been substantial land loss in this region of Elgin County. Refer to Figure C.2 for a picture of the lakeward most row of trailers. At present, there is no formal programme (e.g., bylaw, policy, legislation) in place to notify these individuals of the risks they face and relocate these assets before they are lost in the next bluff failure.

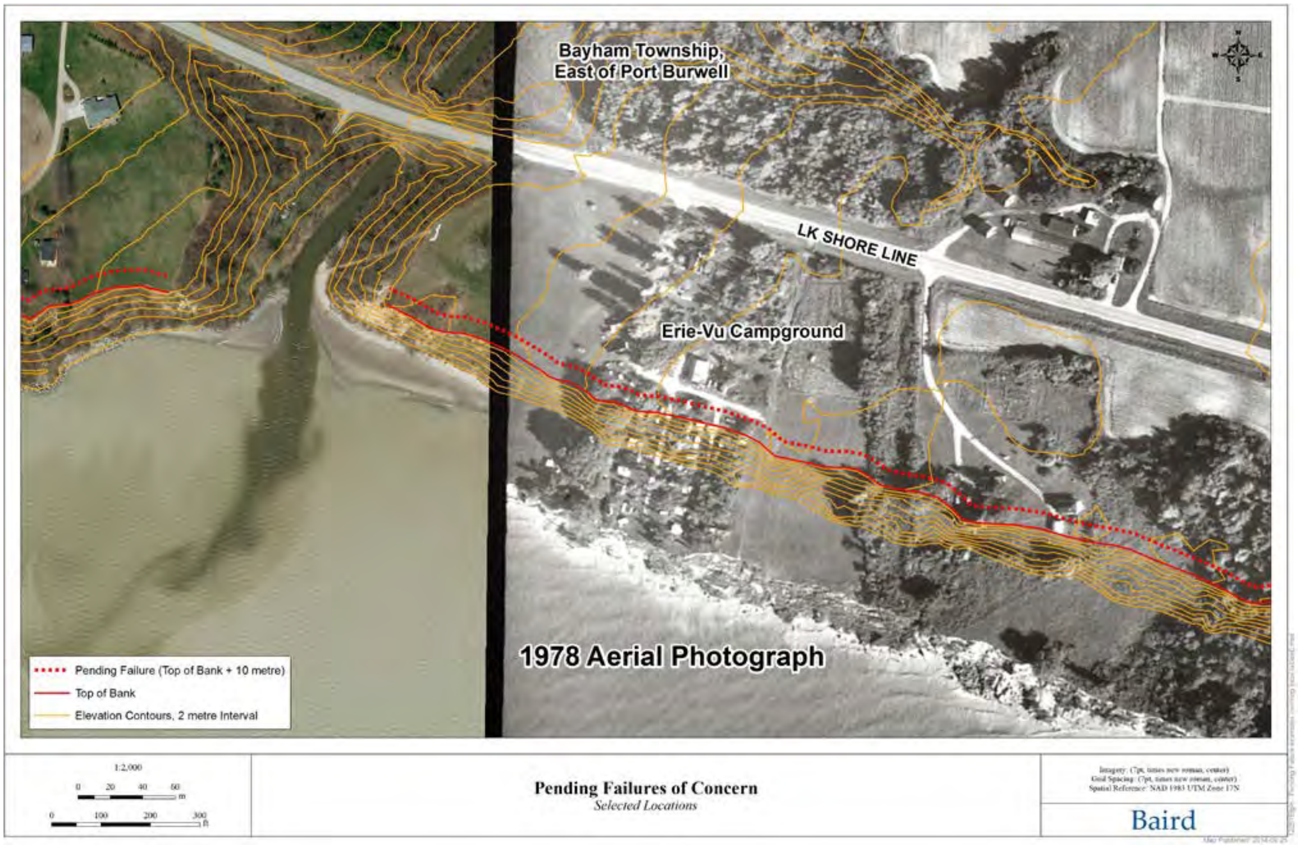


Figure C.1 1978 Aerial Photograph and 2010 Bluff Crest Position at Erie-Vu Campground

Figure C.2 Trailers Located in Close Proximity to the Bluff Crest

A related issue is decommissioning relocated or abandoned buildings. For example, refer to the poured concrete building foundation in Figure C.3 and the old buried fuel tank in Figure C.4. Without a formal policy to ensure the orderly and thorough decommissioning of residences, buildings, utilities, etc. when threatened by erosion, unwanted debris will eventually end up in the lake with potentially serious environmental consequences.

Figure C.3 Concrete Foundation from Abandoned House Exposed in Bluff Crest

The final issue discussed was the issue of safe access to emergencies on hazardous lands. For example, in locations with buildings in close proximity to the bluff crest, it may not be safe to bring heavy emergency vehicles to the site. For example, the application of water to deal with a structure fire and surcharging the crest with a heavy vehicle could trigger a large slope failure. The Technical Advisory Committee and emergency responders agreed that further collaboration was required between the County, Municipalities and CAs to address the communication of hazards and risks in the community.

Figure C.4 Old Fuel Tank Exposed in Eroding Bluff Crest

Public Open Houses

Three public open houses were held in Elgin County August 26th to the 28th, 2014. The venues included E.M. Warwick Conservation Area in the Municipality of West Elgin, the Port Stanley Arena and the Royal Canadian Legion in Port Burwell. At each location an afternoon and evening session was held. A formal presentation was provided on the development of the SMP, followed by a question and answer session. A select number of the draft hazard maps were on display for the attendees to view.

Feedback Question and Answer

The following summarize some of the common questions and comments received following the formal presentation and documented on the comment sheets:

1. *Question*: Will the erosion of the bluffs ever stop? *Answer*: No. For eroding cohesive shores, the erosion process never stops.

2. *Question*: We pay taxes to three levels of government, why doesn't the government fix this problem. *Answer*: This question is beyond the scope of the investigation, which is focused on mapping hazardous lands and developing a SMP as per the Conservation Authorities Act. The participant was directed to forward the query to their Federal MP and Provincial MPP.

3. *Comment*: We can't afford to lose any more valuable farmland. *Reply*: This question was beyond the scope of the investigation. The participant was directed to forward the question to the Federal MP and Provincial MPP.

4. *Comment*: A 100 year planning horizon for the development setbacks is good but we are just delaying the problem. Maybe the planning horizon should be 1,000 years. *Reply:* Officially changing the planning horizon for the SMP would require a change to the Conservation Authorities Act (which is beyond the scope of the investigation). However, there is nothing stopping the Elgin County and the Municipalities from taking a longer perspective to land use planning. For example, the lands between the port communities could be zoned solely for agriculture, with no possibility for land subdivision to facilitate additional residential development (e.g. estate lots along the coast).

5. *Question*: General support for the SMP. However, efforts should be directed to reducing the long-term erosion rate with bio-engineering techniques and buffer strips of native vegetation. *Answer*: The comment was noted and has become part of our future recommendations (i.e., pilot projects on slope stabilization using buffer strips, bioengineering techniques and native vegetation).

Comment Questions

The following comments and questions were submitted during the open house meetings:

1. *Comment*: The SMP focuses on hazard mitigation planning. A truly integrated SMP would do more, such as protecting ecosystems and habitat restoration projects. *Reply*: Historically SMPs in Ontario have had a narrow focus on hazard mitigation. However, this SMP has adopted the principles of integrated coastal zone management and ecosystem based management to ensure a holistic and sustainable approach to planning along the coast in Elgin County is followed in the future.

2. *Comment*: Attendee would like more information on erosion processes. *Reply*: Directed to review the SMP once released, as it would contain this information.

3. *Comment*: Would like information on shoreline protection structures. *Reply*: Numerous references are available on the Internet, including the USACE Coastal Engineering Manual (http://chl.erdc.usace.army.mil/cem).

4. *Comment*: Would like to see the map corresponding to their property. *Reply*: Final maps will be available via the CA websites.

5. *Comment*: Shoreline protection structures should not cause negative impacts to adjacent properties or the downdrift coastline . *Reply*: This is one of the objectives for the SMP.

6. *Comment*: SMP should allow for the protection of existing development in the port communities. *Reply*: Agree and this is reflected in the recommendations for the SMP.

7. *Comment*: People should be allowed to protect their shoreline property and assets. *Reply*: Agree, provided it does not generate negative impacts to the adjacent or downdrift shoreline. As discussed in Section 2.2, building shoreline protection on eroding shorelines causes negative impacts to adjacent and downdrift shorelines.

APPENDIX D

LTVCA HAZARD MAPS
(*Provided in oversized format only; contact the LTVCA for further information*)

APPENDIX E

KCCA HAZARD MAPS
(*Provided in oversized format only; contact the KCCA for further information*)

APPENDIX F

CCCA HAZARD MAPS
(*Provided in oversized format only; contact the CCCA for further information*)

APPENDIX G

LPRCA HAZARD MAPS
(*Provided in oversized format only; contact the LPRCA for further information*)