Shoreline Development and Management within the Areas of Interference of Bluff Hazards Adjacent to Lake Huron

by

Mollie Kuchma

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ABSTRACT

SHORELINE DEVELOPMENT AND MANAGEMENT WITHIN THE AREAS OF INTERFERENCE OF BLUFF HAZARDS ADJACENT TO LAKE HURON

Mollie Kuchma
University of Guelph, 2014

Advisor: Dr. John FitzGibbon

Shoreline ecosystems in the Great Lakes basin are among the most dynamic ecosystems on the planet. As climate change and development pressures continue to threaten natural hazards, such as the bluff hazards on the Lake Huron shoreline, a comprehensive shoreline management plan needs to be developed to guide future and existing development in the areas of interference adjacent to the hazard.

This paper aims to provide recommendations guiding the future of shoreline development and management along the Lake Huron shoreline within the Maitland Valley Conservation Authority watershed jurisdiction in Huron County. These recommendations take into consideration both protection and prevention measures, contributions to bluff hazards specific to the study area as well as information provided from professionals working in shoreline ecosystems within the Great Lakes basin.
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1.0 Introduction

More than half of Ontario’s population lives in municipalities with shorelines and access to freshwater resources (Byrne, 1998). Water resources in southern Ontario draw recreational and seasonal visitors from all over Canada and the northern United States to cottages and other recreational and seasonal homes throughout the summer months each year. With this influx of people comes increased stress on shoreline environments that negatively impact the local watershed, terrestrial and aquatic ecosystems and threaten increased risk of hazard features.

The Lake Huron shoreline is currently experiencing high levels of erosion at incremental rates from both natural and anthropogenic causes. Intense, frequent storms attributed to climate change as well as anthropogenic stresses are causing an increase in the rate of erosion along the shoreline. Natural processes such as erosion, slumping as well as new development and renovations to existing dwellings are producing negative results on this already sensitive shoreline. Because of this, the Lake Huron shoreline is experiencing high rates of shoreline and property loss.

Nearshore areas are of special interest to researchers studying natural hazards, such as bluff erosion, because of the interactions and relationships between natural processes and human tendencies. This location serves as a boundary between an open-water system and a terrestrial environment that is often negatively impacted by anthropogenic stressors that influence material exchange such as sediment transport, nutrient transport and pollution (Goforth & Carman, 2005). Understanding this relationship can provide valuable insight into policies and mechanisms for effective land-use planning in hazard lands. It is important to note that a systems approach must
be used to fully understand nearshore hazard areas as there are many contributing influences from both people and the natural environment.

Effective land-use planning and management is necessary in order to be proactive towards the changing environment. It is difficult to be retroactive and find solutions for existing problems, so it is important to have a proactive approach that attempts to minimize the impacts that natural hazards may have in the future. Because of this, identifying a suitable action plan that incorporates land-use planning, policy and an understanding of the hazard process can minimize the risk of loss of life and property as well as assist municipalities and conservation authorities in proactive planning practices.

Figure 1 identifies the framework for the research project. It identifies the methods and procedures that were used and the findings that guided the formulation of the recommendations.
2.0 Summary

This research project will identify a suitable management plan for shoreline development in areas of significant erosion hazard along the Lake Huron shoreline. The area of interest for this project is the Canadian shores of Lake Huron in the township of Ashfield-Colborne-Wawanosh (ACW) in the County of Huron. This stretch of shoreline is highly active and currently experiencing increased instances of erosion due to many contributing natural and anthropogenic factors. This research project will analyse the current state of the shoreline within the study area as well as provide recommendations and Best Management Practices (BMPs) that incorporate protection and prevention methods that will protect and enhance the shoreline as well as promote appropriate shoreline development and management within the study area.

The area in which this study will be conducted is governed by Huron County and the Maitland Valley Conservation Authority (MVCA). It is the shared responsibilities of these institutions to ensure that development adhere to regulations regarding shoreline development and management. These governing authorities will ensure that development adheres to municipal Official Plan and Zoning By-law documents as well as provincial regulations such as the Planning Act and the Conservation Authorities Act, specifically section 164/06 for Maitland Valley Conservation Authority policies for Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses.

A number of research methods will be used to formulate the structure of this research project. A literature review and historical data will be analyzed to identify characteristics of the study area and provide context in which the research study will take place. A review of current policies and regulation that govern development in hazard areas will identify gaps in legislation and provide insight into areas that need to be reconsidered. Existing policies are designed to
mitigate the effects of new development along the shoreline; however existing structures may still be prone to bluff failure and negative impacts associated with shoreline erosion. Through the use of a questionnaire and key informant interviews with professionals that have experience with shoreline hazards, recommendations will be made for effective planning along the shoreline.

The Provincial Policy Statement offers definitions of terms that will be used throughout this research paper. It is important that the terminology used within this paper remains consistent with the terminology used in the Provincial Policy Statement. As such, the Provincial Policy Statement (2014) offers the following definitions:

**Development:** means the creation of a new lot, a change in land use, or the construction of buildings and structures requiring approval under the Planning Act (p. 41);

**Erosion Hazard:** means the loss of land, due to human or natural processes, that poses a threat to life and property. The erosion hazard limit is determined using considerations that include the 100 year erosion rate (the average annual rate of recession extended over a one hundred year time span), an allowance for slope stability, and an erosion/erosion access allowance (p. 41);

**Hazardous Lands:** means property or lands that could be unsafe for development due to naturally occurring processes. Along the 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 (p. 43);

**Protection Works Standards:** Means the combination of non-structural or structural works and allowances for slope stability and flooding/erosion to reduce the damage
caused by flooding hazards, erosion hazards and other water-related hazards, and to allow access for their maintenance and repair (p. 47); and

**Redevelopment:** means the creation of new units, uses or lots on previously developed land in existing communities, including brownfield sites (p. 47).
3.0 Purpose & Significance

The Great Lakes shorelines are among some of the most dynamic ecosystems in the world. These coastal areas are home to many significant biotic and abiotic features that are threatened due to the pressures of development as well as by natural processes that are becoming increasingly frequent and intense due to climate change (Lawrence, 2006). New development and redevelopment of existing dwellings further complicates the situation by adding increased pressures to an already troublesome problem.

The purpose of this research project is to offer recommendations to planning authorities that are currently experiencing and dealing with development in highly hazardous and erosive areas. Further, to provide a proactive approach to planning for development in hazard lands for the future, specifically along the Lake Huron shoreline in the Great Lakes basin. The shoreline of the lower Great Lakes, which includes Lake Huron, Lake Erie and Lake Ontario, are composed of large sections of shoreline bluffs that amount to more than 40% of the total shoreline length (Lawrence, 1994).

The significance of this research appears as emerging climate trends continue to threaten valuable ecosystems (such as coastal environments) and intense storms become more frequent, it is important to provide guidance for planning in hazard areas in the future. As well, it is important to provide recommendations for emergency preparedness planning in the event of imminent landsliding or highly active erosion, as these processes will continue to become more common and threaten property owners more frequently.

Maitland Valley Conservation Authority relies on their policies for shoreline development under the Conservation Authorities Act to regulate development along the Lake Huron shoreline. A Shoreline Management Plan has not been completed for this watershed;
therefore, a clear direction for development along the shoreline has not been determined for development along the Lake Huron shoreline in Maitland Valley’s watershed jurisdiction.

Shoreline Management Plans were introduced upon recommendation from an advisory group appointed by the Province of Ontario after high water levels in 1986 resulted in immense shoreline damage from storms and wave action (Ausable-Bayfield Conservation Authority, 2000). A Shoreline Management Plan is developed to reduce or eliminate damage as a result of development in areas of interference adjacent to hazard lands. According to the Ausable-Bayfield Conservation Authority Shoreline Management Plan (2000) these plans:

1. Identify hazard areas associated with flooding and erosion;
2. Establish setbacks for development; and
3. Provide shoreline management options for both new and existing development.

As such, it is evident that Shoreline Management Plans provide a much more detailed document, guiding direction for shoreline development and management away from the hazard and providing justification for land-use designations, setbacks and zoning. By relying solely on policy, the Lake Huron shoreline within Maitland Valley Conservation Authority’s jurisdiction unfortunately does not have a clear direction for future development and management of its shoreline and hazard lands.
4.0 Goals

The goals of this research project are to:

1. Develop recommendations for development in areas of interference, adjacent to hazard lands, through protection and prevention mechanisms; and
2. Identify gaps in current policies and provide recommendations for more effective land-use planning along hazardous shoreline areas in the future.
5.0 Objective

From this research, the following objective will be met:

1. Recommendations for future development in areas of interference, adjacent to hazard lands based on:
   a) A review of the literature;
   b) Identification of existing policies and regulations; and
   c) Experience from professionals currently working with shoreline development in the Great Lakes basin.
6.0 Study Area

The Great Lakes ecosystem is the largest source of fresh water on earth, holding a volume of approximately 23,000 km$^3$ of water (United States Environmental Protection Agency, 2012). Carrying the third largest volume of water in the Great Lakes, Lake Huron has approximately 3,540 km$^3$ of water, ranks highest among the lakes with the largest land drainage area at 134,100 km$^2$ and has the largest shoreline length spanning 6,157 km (United States Environmental Protection Agency, 2012). The length of the lake is approximately 330 kilometers long with an average depth of 59 metres (F.J. Reinders & Associates, 1989). These characteristics are interesting and of great importance when studying erosional processes and planning for future and existing development in hazard lands. It is important to understand the characteristics of a landform in order to understand the processes that naturally affect this ecosystem.

The Lake Huron shoreline is and has been highly susceptible to shoreline erosion because of its exposure to wind and water. Located in Southwestern Ontario, the bluffs present along the Lake Huron shoreline are largely composed of cohesive sediments including glacial till, clay and silt (Lawrence, 1994). St. Joseph’s till is the main form of surficial deposit along the Lake Huron shoreline and is resistive to erosion, except when exposed to wind and precipitation, often experienced in the study area, which leads to runoff, mass wasting, abrasion and rapid removal of sediment (Lawrence, 1994).

6.1 The County of Huron
The County of Huron is a rural county located in Southwestern Ontario with a land area of 3,399 km² and a population density of 17.4 people per square kilometer (Statistics Canada, 2012). Often referred to as ‘Ontario’s West Coast’, The County of Huron is largely comprised of agricultural land use with several small urban communities and recreational & seasonal development along the shoreline. With a 2011 population of 59,100, the County of Huron saw a minor decrease (0.46%) in population size since 2006 (Statistics Canada, 2012). This can likely be attributed to the current trend of Canada’s youth leaving rural Ontario communities for urban communities throughout the province.

The local government in the County of Huron is considered a two-tiered municipal government consisting of an upper tier (the county) and lower tiers (local municipalities). The County is responsible for land use planning, emergency services such as fire and police as well as maintenance of county roads, while the lower tier municipalities are responsible for recreation programs, park maintenance, waste programs and municipal road maintenance (Huron County Community Portal, 2012c). The lower tier municipalities in the County of Huron include the townships of Ashfield-Colborne-Wawanosh, Howick and North Huron, the municipalities of Bluewater, Central Huron, Huron East, Morris-Turnberry and South Huron as well as the Town of Goderich. This research project will focus on the shoreline in the township of Ashfield-Colborne-Wawanosh, between the towns of Goderich and Amberley.
Historically, the County of Huron was known as the Huron Tract, an area used by Mohawk and Chippewa First Nations Peoples (Huron County Community Portal, 2012b). The British Crown purchased the Huron Tract from the Chippewas and sold it to the Canada Company around 1827 for the purpose of selling land to colonists in Upper Canada (Huron County Community Portal, 2012b). It is suggested that this was the beginning of settlement in the County of Huron, however, 1880 represents the time when the county was to be settled and established in a way that reflects current times (Scott, 1966). The County of Huron is currently the most agriculturally productive county in Ontario which is reflected in the number of descendants of original settlers that continue to farm in the county today (Huron County Community Portal, 2012b).

6.2 Ashfield-Colborne-Wawanosh Township

Ashfield-Colborne-Wawanosh is one of three townships in the County of Huron, located on the northwest corner of the County, spanning the Lake Huron shoreline from Goderich to Amberley. Ashfield-Colborne-Wawanosh had a 2011 population of 5,582, a 3.2% increase from 2006 (Statistics Canada, 2012). The township is about 587 km² with a population density of 9.5 people per square kilometer, significantly less than that of the County (Statistics Canada, 2012).

A lower-tier municipality within the County of Huron, Ashfield-Colborne-Wawanosh, was formed on January 1, 2001, from the amalgamation of the townships of Ashfield, Colborne
and West Wawanosh (Ashfield-Colborne-Wawanosh, 2013). The township has its own Official Plan and comprehensive Zoning By-law that it follows. The Official plan was adopted in 2003 then updated in 2013 (Ashfield-Colborne-Wawanosh, 2013). It falls within conformity with the Provincial Policy Statement and the County of Huron Official Plan. The Comprehensive Zoning By-law was passed on June 3rd, 2008 under section 34 of The Planning Act (Ashfield-Colborne-Wawanosh, 2009). This document provides the township with regulations that control land use and related matters that conform to the Official Plan. It is under the Ashfield-Colborne-Wawanosh Comprehensive Zoning By-law and Official Plan that development along the Lake Huron shoreline within the study area must conform to.

6.3 Maitland Valley Conservation Authority Watershed

The Conservation Authorities Act was created by the Government of Ontario in 1946 as a response to concern over the state and well-being of the environment (Conservation Ontario, 2009). As a result, Maitland Valley Conservation Authority was formed in 1951 and covers the watershed and drainage areas of the Maitland River, Nine Mile River, Eighteen Mile River and the shoreline of Lake Huron (Maitland Valley Conservation Authority, 2014).

Maitland Valley Conservation Authority (MVCA) is one of 36 Conservation Authorities in Ontario, spanning approximately 2,500 kilometers of Southwestern Ontario (Rush et al, 2004).
The organization works at a local watershed level to enhance natural features within the watershed and develop programs and policies that protect life and property from damage due to natural hazards such as flooding and erosion. In order to do so, MVCA regulates natural and hazardous features under Section 28 of the Conservation Authorities Act and works closely with member townships and municipalities to ensure that development occurs in the most effective and safe way possible. This will be discussed in further detail later in this paper.
7.0 Methods & Procedures

Multiple methods will be used to evaluate the current state of the Lake Huron shoreline, the causes and characteristics of the natural processes occurring as well as the current policies governing land use development and planning. A literature review of existing research and historical information will provide background information, scope and context for the research project. It is important to review the research that has been done historically, as many natural processes are cyclical and are likely to occur again. Understanding existing processes is beneficial when planning for the future. Information from existing research can provide insight into existing challenges & deficits and shed light on new methods to address current issues in land use planning along the shoreline.

The use of questionnaires and key informant interviews with stakeholders involved with development along the shoreline within the Great Lakes basin will provide a more focused opinion of the current issues affecting the Lake Huron bluffs within the study area. These methods differ from the information obtained from a literature review because often trends that occur in real life scenarios can differ from analytical information and models. The expertise provided by professionals working with development in hazard lands on a regular basis provide alternative information not obtained through academic research and help mould recommendations from people working with current policies and legislation in real life scenarios.

7.1 Literature Review

The specific area being studied for the purpose of this research project is the area of interference immediately adjacent to a bluff hazard. That is, the area at both the top of the bluff and toe of slope where development tends to take place. The Maitland Valley Conservation
Authority Shoreline Policies (2009) identify three components of a cross section as illustrated in Figure 5.

Section 1 of the cross section illustrates the area of the shoreline from Lake Huron to the toe of the slope. Section 2 illustrates the area of the shoreline that is considered to be the bluff hazard. This section extends from the toe of the bluff at the bottom of the slope up to the stable slope allowance. Finally, section 3 illustrates the area of the stable slope allowance to the 100 year erosion risk limit. The Maitland Valley Conservation Authority uses the 100 year erosion risk limit as the setback limit for development along the shoreline, however policies for redevelopment or new development within this limit may be permitted subject to certain conditions, such as setbacks from the stable top of bank.

While there are dwellings that exist within section 2 of the cross section, no new development is permitted within area. For the purpose of this research project, section 1 and section 3 are considered the areas of interference adjacent to the hazard, as it is development within these sections that poses risk to life and property due to slope failure. The
recommendations that will be made throughout this research project will focus on protecting the properties and lives of property owners that reside within these sections of the shoreline in the Maitland Valley Conservation Authority jurisdiction in Ashfield-Colborne-Wawanosh, County of Huron.

A literature review is a necessary component of the preliminary stages of a research project that needs to be undertaken to understand the research topic, what has been done by researchers previously, what knowledge is available and what gaps exist. A literature review summarizes the information that is available on a specific research topic from the review of academic works previously published in books and journals and provides for a broad body of information available on a specific topic (Rhodes, 2011). According to the Learning Commons at the University of Guelph (2004), a literature review is an excellent starting point for a research project because it provides relevant, important and valid information on a topic. Further, it provides insight into the research that has previously been completed, identifies key findings and ensures that duplicate research does not occur (The Learning Commons, 2004).

An important component of a literature review is identifying the relevant information and defining specific vocabulary necessary to obtain relevant information (Rhodes, 2011). It is important to identify the vocabulary that is used and commonly agreed upon by researchers and professionals in an area of study to ensure that the information being obtained is relevant to a particular discipline. Using the correct terms and vocabulary can also assist when searching through databases to remain consistent in searches. For this research project, keywords such as ‘bluff erosion’, ‘Great Lakes basin’, ‘shoreline management’, ‘bluff hazard’ and ‘Lake Huron’ were used most often. This ensured that consistency throughout the research project.
For the purpose of this research project, a literature review was a necessary starting point as it identified the research that has previously been completed on shoreline development and management along the Lake Huron shoreline as well as on other Great Lakes in Ontario and on hazardous lands around the world. The literature review also identified gaps in the literature and provided insight into the direction that the research may be headed. By not doing so and not possessing this wealth of information, the researcher is put at a disadvantage when completing their own research (Boote & Beile, 2005).

A review of the literature associated with shoreline development and management was undertaken in the 2013 summer semester as a starting point for this research project. This literature review identified the issues that exist within the study area, causes of erosion and bluff hazards, current policies and regulations that are in place to protect and guide development as well as what is being done in other municipalities experiencing the same or similar issues on their shorelines. The literature review also guided the formation of this research project, identifying which specific areas of research should be focused on and what the goals of this research project should be. As such, it was identified that in order to provide sound shoreline management practices, it is important to understand protection and prevention methods that currently exist and that should exist. Through a review of the literature, the benefits and constraints associated with protection and prevention methods were identified and evaluated using characteristics specific to this study area. By doing so, sound recommendations for the future of shoreline development and management on the Lake Huron shoreline in Ashfield-Colborne-Wawanosh, Huron County can be made that will assist in guiding development and shoreline management in the coming years.
The basis of this research projected was formulated around the Lake Huron shoreline processes study that was undertaken by F.J. Reinders and Associates in 1989, which ultimately shaped the scope of the research and outlined the direction to take for the literature review. In the mid-1980’s, the Ontario Ministry of Natural Resources had developed the Shoreline Management Review Committee and the Shoreline Management Advisory Council to review the current state of the Great Lakes following high water levels and ultimately designated the local Conservation Authority as the regulatory authority responsible for the shoreline. As such, F.J. Reinders and Associates was contracted by the local Conservation Authorities with jurisdiction on Lake Huron, Ausable Bayfield Conservation Authority, Maitland Valley Conservation Authority, St. Clair Region Conservation Authority and Saugeen Valley Conservation Authority, to evaluate the current state of shoreline processes. The report recommended that updates continue to be made regarding the health and future development of the shoreline as research continues. However, since then no significant research has been undertaken to the calibre of this report.

A common trend and gap in the research that was identified in the literature review was that much of the research on this topic was conducted in the late 1980’s and early 1990’s. It became evident that regulatory changes or a major event occurred and triggered research in this specific research area, such as the high water levels from 1985-1987 in the Great Lakes (F.J. Reinders and Associates Canada Limited., 1989). By the mid-1990’s, very little research was being done and since then, very little has been completed. This is alarming, especially due to the dynamic nature of bluffs and erosion hazards. In many areas of the study area, bluff failure has occurred over recent decades and will continue to occur at increasing rates throughout throughout the coming years.
The literature review identified the coastal processes that are characteristic of the Lake Huron shoreline. Each of the Great Lakes differ greatly in their shoreline processes, properties and characteristics, so it was important to first understand specific information relating to the Lake Huron shoreline. The literature review further identified the main causes and contributors to erosion specific to this area of the Great Lakes basin. It was identified that toe erosion as a result of wave action and fluctuating water levels, saturated overland flow and mass movement of material were the leading causes of erosion with other factors such as gully formation and development pressures contributing as well.

Based on the information received from the literature, this research project attempts to use much of the research that was done in previous decades and existing information regarding characteristics of the study area as well as current regulatory policies and measures to guide development and management recommendations for the County and Conservation Authority as they continue to monitor existing bluff conditions and mitigate the effects of bluff erosion within the study area.

7.2 Questionnaire

Questionnaires are a quick and simple way to gain information about a specific topic with minimal bias from those that are completing the survey. Questionnaires can include a range of simple close-ended questions that do not provide room for explanation or open-ended questions that allow the respondent to provide an answer based on their own perception of the question. While questionnaires are very practical, they also allow for a large amount of data accumulation within a relatively easy and short timeframe (Ackroyd & Hughes, 1981).
One shortcoming of using questionnaires is the issue surrounding bias and truthfulness. Through the use of questionnaires, there is unfortunately no confirmation of truth, validity or reliability of the source, as well as indication of any external influences (Ackroyd & Hughes, 1981). To overcome this inadequacy, the questionnaire used in this research project was only sent to Ontario Conservation Authorities with shorelines adjacent to the Great Lakes as well as engineering firms in southern Ontario that expressed experience working with shorelines or erosion. Respondents were required to provide their position and organization as a form of validity for this research as it was expected that the respondents had experience working with development on erosive slopes. As another method used to decrease bias from the respondents was that only a vague description of the research project was provided and questions were kept short, concise and simple. This was intentional as it was expected that respondents would provide different responses had they known the intent of the project and the direction of the research. It was intended that the respondents would answer these questions considering previous experience that they have personally in their own working environments.

The questionnaire distributed for this research project played an integral part in determining the factors involved in land use planning on erosive slopes and provided insight into the influences that both planners and engineers take into consideration when reviewing applications for development on hazard lands. The questionnaire was sent out to Conservation Authorities, Municipalities and engineering firms that expressed experience in the subject area. The respondents were asked to rank 10 criteria that may be influential factors when considering development in hazard lands. The respondents were then asked to comment on their choice of ranking and provide any additional criteria that may also be influential for development in hazard lands. These criteria were chosen based on knowledge gained from the literature review that was
conducted. It was anticipated that from the results of this questionnaire, there would be a clear direction of the factors that should be focused on in the development of recommendations for shoreline management.

The questionnaire provided a complimentary approach to the literature in regards to obtaining information. The literature review provided academic and theoretical information regarding the state of the shoreline, its characteristics and what research has been done. The questionnaire provided experiential knowledge based on real world examples and observed situations that will contribute to providing recommendations for the direction of shoreline development and management in the study area.

7.3 Key Informant Interviews

Key informant interviews are a good source of qualitative, specific, first-hand knowledge of a topic from leading professionals in a field of study (USAID, 1996; Barker et al, 2005; UNCF, 2006). Generally, these interviewees are chosen based on their professional experience, community involvement, willingness to participate and knowledge of the issues at hand (Tremblay, 1957; Elmendorf & Luloff, 2006). Using these criteria, professionals with experience in development along erosive slopes and hazard lands on the Great Lakes were obtained as interviewees. Six interviews took place with interviewees comprised of planners, engineers and scholars, all with vast amounts of experience dealing with shoreline development and management in hazard lands. It was important to have a variety of interviewees from varying backgrounds as shoreline development is dynamic and involves professions from many disciplines.
A strength of key informant interviews is the ability to provide descriptive information that assists in the decision-making process, which also provides a basis for new ideas that have not been previously identified (USAID, 1996). This information is also important in building and developing a collaborative support system for further research (Elmendorf & Luloff, 2006). Because the research interests of this project are in the preliminary stages, these interviews will provide new ideas and opportunities for further networking as the research develops.

The primary advantage of key informant interviews is that the qualitative information provided by interviewees is very detailed and provides more information than other methods of data collections (Boyce & Neale, 2006). While it is recommended that interviewers approach the interview with a written topic guide, key informant interviews allow participants to talk freely about other information that may come to mind (Barker et al, 2005). Due to the complexity and multi-causal nature of shoreline development and management, having the opportunity to talk freely about other ideas and information that comes to mind when proposed with a question will help identify new ideas and strengthen existing arguments.

One inadequacy associated with key informant interviews that would affect the quality of information in research includes the inability to generalize data (USAID, 1996; Barker et al, 2005; Boyce & Neale, 2006). When asking open-ended questions, there is a high likelihood that opinion and bias are likely to occur, leading to multiple ideas, solutions and outcomes. These are common weaknesses associated with key informant interviews that are based on both the opinions of the interviewer and interviewee (USAID, 1996; Boyce & Neale, 2006). Furthermore, qualitative data is often hard to quantify as numbers cannot be placed on opinions and values (USAID, 1996; Barker et al, 2005; Boyce & Neale, 2006). Because of this limitation, it is
important to use this statistically insufficient information in interviews to validate and further strengthen previously obtained knowledge and ideas (Tremblay, 1957; USAID, 1996).
8.0 Findings

The findings of the literature review, questionnaire and key informant interviews played an integral part in the design of the research project and guided the formulation of recommendations for future shoreline development and management within the study area. As demonstrated in the research framework in Figure 1, each of the methods undertaken in this research project was necessary and influential in the design of the following research method. The results of the literature review were necessary for the design of the questionnaire and the responses to the questionnaire were necessary for the development of questions for the key informant interviews. Finally, the findings from each of these processes assisted in the formulation of recommendations for the future of shoreline development and management within the study area.

8.1 Questionnaire

Following the completion of the literature review, an email was sent to professionals with experience dealing with shoreline development and management in the Great Lakes basin. This email, seen in Appendix A, offered a brief description of the research project and asked for involvement from these agencies. It was important to gain support from professionals with experience in this field, as it is a very specialized and specific hazard that is being dealt with.

There were 23 individuals that responded to the questionnaire (Appendix C). Of these respondents, 15 were from Ontario Conservation Authorities, 4 were from Municipalities, 3 were from Engineering Firms and 1 was from an educational institution. Further, 13 of these respondents identified themselves as planners, 4 identified themselves as engineers and 6 identified themselves as others, which included biologists, ecologists and a University professor. The number of individuals that responded to the questionnaire was considered to be a successful
response rate, as expertise in shoreline development is not widely experienced. It is difficult to obtain unbiased and legitimate responses if the respondents do not have experience in the subject field.

The respondents were asked to rank ten factors associated with development (seasonal, recreational and residential) in areas where active shoreline erosion exist from 1 (most important) to 10 (least important). The results seen in Table 1 identify the average ranking that was given to each of the criteria identified in Appendix B. There appeared to be a general consensus among the respondents in terms of which criteria were most important and which criteria were the least important.

It was identified that soil type & composition, the recession rate of the slope and the slope angle were the three most important criteria associated with development in areas where active erosion exists. This was not surprising as it was assumed professionals dealing with shoreline development in hazard lands would possess knowledge and understanding regarding erosion processes and characteristics. As erosion is a natural process, these are important factors to understand before implementing and enforcing policies and regulations to manage development in areas of interference adjacent to these features.

From a planning perspective, the most surprising result was the least important factor was identified as the size of the property. Property size is important for location and development purposes within municipal documents, especially in areas of active erosion, because having room for development or relocation is important. It is also surprising to see that regardless of the fact that the majority of respondents were planners, criteria relating to development such as proximity to stable slope, distance to 100 year erosion risk limit and presence of septic vs. pump-out sewage systems, appeared to rank so low. These are surprising results as these are criteria and
factors that planners deal with on a regular basis when reviewing compliance with policies and regulations, including setback requirements.

Table 1 Questionnaire Responses

The respondents were also asked to provide any additional comments regarding justification for their ranking or comments regarding other factors to consider that are important. This is important information, especially in the planning discipline, as often experiential information and knowledge can differ greatly from theoretical and academic knowledge. It was encouraging to see that many comments reflected indication that the criteria identified are, in fact, important criteria to take into consideration when dealing with shoreline development and management. Other criteria that were identified as important included man-made devices, underground drainage systems, shoreline protection works, presence of groundwater and wave uprush, which will be reviewed and discussed in further detail later in this paper.

The questionnaire was an important method to use in the formulation of this research project because of the value it added to the construction of the questions for the key informant
The responses that were provided in the questionnaire guided the development of questions that were discussed during the interview in order to elaborate on the findings and discuss the conclusions that were made.

### 8.2 Key Informant Interviews

The key informant interviews performed for this research project included a series of specific questions (Appendix D) asked to each individual, but also allowed room to explore other areas of research related to development in areas of interference adjacent to hazard lands. Depending on the position, area of research or location within the Great Lakes basin, experiences may differ from interviewee to interviewee. By allowing room for open-ended questions, new topics and ideas can be expressed. This was especially helpful as the responses greatly differ between planners, engineers and academic researchers. As expected, planners were generally more focused on the policy and legislation implications surrounding development on erosive slopes, engineers were more focused on the physical processes and efforts to reduce or mitigate erosion of the bluffs and the responses from academic researchers were largely focused on trends, recommendations and predictions for the future.

The first question asked if development adjacent to hazard lands was considered to be good planning practice. The responses to this question varied greatly. One informant stated that no, it was important to locate development outside the hazard; one informant suggested that it is good planning practice, as long as it reduces long term economic and social costs; and three other informants generally agreed that with proper setbacks and additional studies such as geotechnical assessments, it is considered to be good planning practice.

The informants were asked to identify the majority stakeholders in shoreline development. Considering that each of the informants come from government agencies or
educational institutions, it was surprising to see that there was only one common answer among the six informants: the landowner. Very few suggested that there were any other stakeholders involved in development in areas of interference adjacent to the hazard. These responses suggest that these professionals do not see themselves as stakeholders in this process. By not seeing themselves as stakeholders, it is difficult to take pride and ownership over development that is occurring adjacent to these hazard lands.

The informants were asked if they felt that they were able to influence decisions that are made within their jurisdiction, or if they felt bound by the regulations they are governed by. Further, they were asked what regulatory changes they would make, if possible. Each of the informants stated that they felt bound by regulation, however one informant suggested that staff try to influence development proposals before applications are submitted to ensure that proposals met policies. This is an interesting approach to development applications and one that is highly recommended. By doing so, the applicant is aware of the regulations that control the proposed development and relationships are built between the agency and property owner. The regulatory changes that were identified suggested that enforcement for those violating regulation be stronger to deter landowners from undertaking works that may actually negatively impact the hazard or the hazard on adjacent properties.

When asked if current regulations were too lenient or too strict, the most effective answer was that regulations are inconsistently applied. This is an all too common case, where policies are interpreted differently by different professionals. This means that what may be permitted by one professional, may not be permitted by another. Strengthening terminology and policies to reduce the necessity to interpret regulations would allow for a more consistent effort throughout the province.
The informants were asked whether stewardship initiatives and Best Management Practices or policies and regulations were the most effective approach to reducing anthropogenic influences on bluff hazards. There was a general consensus that both were required to be successful, but education was key in ensuring landowners manage risk on their own properties. It was suggested however that stewardship and Best Management Practices occur in conjunction with input from professionals to ensure that what is being done on private property is not contributing to further instability or erosion on their property.

Finally, the informants were asked who becomes liable if a dwelling is compromised due to safety concerns as a result of slope failure. It was suggested that it is the landowners liability should slope failure occur. It is assumed that when permitted, development conforms to policies that were in place at the time of permission and would therefore be based on the best available information at that time. This is a very solid conclusion, as many jurisdictions deal with liability suits and issues. If an agency permits development based on the best information available at that time, it is very unlikely to know whether or not that same application would be approved at a later time as new information becomes available. As a way of mitigating these issues, the agencies of some informants have introduced an owner acknowledgement for shoreline development that ultimately removes responsibility from the agency and places it on the owner in the event that failure occurs.

It is important to understand the relationship between multiple research methods in order to successfully obtain information for a research project of this magnitude. The information that was obtained from the key informant interviews built on the results obtained in the questionnaire. Without an understanding of the factors involved in shoreline development and management in areas of interference adjacent to a bluff hazard, a clear understanding of the direction of research
would not have been identified and it would have been difficult to formulate interview questions within the scope of this research project.
9.0 Causes of Erosion & Contributions to Bluff Hazards

There are many factors that contribute to shoreline erosion and bluff hazards and cause erosional processes to take place. Erosion is a naturally occurring process that most often occurs when large chunks of sediment or material are lost as a result of mass-movement at the top or toe of the slope (Ritter, 2012; Mier & Garcia, 2011). The process of erosion includes three actions: soil detachment, soil movement and soil deposition (Ritter, 2012). The Lake Huron Shoreline is experiencing erosion at both the base of the slope and top of slope due to the effects of sheet, splash and gully erosion as well as development pressures. Together, these erosional processes contribute to a highly active and erosive shoreline in the study area. This is a huge issue when considering development in the area of interference adjacent to a hazard, because the proposed development is at a very high risk of failure and damage. These erosion processes occur in the study area as a result of short high intensity rain events, wave undercutting at the toe of the slope and runoff from adjacent agricultural land.

Toe erosion, mass movement and saturated overland flow are all types of erosion that occur within the study area. These processes often occur as a result of both natural processes and development pressures. Changes in water level contribute greatly to issues currently occurring along the toe of shoreline, largely as a result of climate change and seasonal variations in precipitation and temperature. Finally, gully erosion provides additional stress on some properties that see erosion along the shoreline, but also occurring perpendicular to the shoreline, affecting them from the sides as well.

It is important to understand the characteristics, morphology and geology of the landscape, the types of erosion that are occurring in this section of the Lake Huron shoreline and
potential causes in order to create a plan and provide recommendations for future development and management of these hazard lands.

This area of the Lake Huron shoreline consists of dolomite and limestone located 28 to 33 metres below the surface, covered by silt, clay and clay/till deposits (Lawrence, 1994). The main surficial deposit along the Lake Huron shoreline is St. Joseph’s till. St. Joseph’s till is relatively resistive to erosion, except when surface runoff, mass-wasting and toe erosion as a result of water levels and wave action occur (Lawrence, 1994). These characteristics are less than ideal for this specific area of the Lake Huron shoreline as the majority of the bluffs in the study areas experience surface runoff as a result of drainage from agricultural fields adjacent to the shoreline, mass wasting due to saturated overland flow and toe erosion from changing water levels and wave action. As a result, the bluffs and erosion hazards in this area, many of which are twenty to forty metres in height, are highly dynamic and prone to failure. According to data from Maitland Valley Conservation Authority, some areas of the shoreline are experiencing mean annual bluff recession rates in excess of 2 metres per year in some locations.

9.1 Toe Erosion

The geometry of a bluff is the result of the function of wave erosion at the toe of the slope (Amin, 2001). Narrow beaches, such as those present along the Lake Huron shoreline in Huron County, are more susceptible to bluff erosion at the toe of the slope due to the decreased amount of protection that the beach system provides. This means that fluctuating water levels and increased wave action have a detrimental effect on erosional processes at the toe of the slope. Toe erosion takes place in section 1 of the slope cross-section as identified in figure 6.
Bluff erosion as a result of high water levels that affect the toe of the slope is a common occurrence along the Lake Huron shoreline. High water levels can increase the amount of sediment being transported as well as allow water to reach the bluff and become exposed to wave action (F.J. Reinders & Associates, 1989). Water levels change throughout the year due to inflow and outflow processes, precipitation and evaporation. Most often, these changes are seasonal, with an increase in precipitation and inflow during the spring melt (F.J. Reinders & Associates, 1989).

Slope height and slope angle are important factors to consider when discussing criteria that contribute to bluff erosion. They are assumed to be accurate measurements and play a large role in predicting stability of the slope (Edil & Shultz, 1982). A high slope angle is less ideal because the slope will continue to erode until it reaches a stable slope of 3:1 (or approximately 33% incline). The higher the slope angle (measured as a function of height over depth of the bluff) the less suitable the property is for development. This is because as the slope continues to erode to reach stable slope, property will continue to be lost. Further, the steeper and the longer
the slope the higher the risk of erosion because of the accumulation of water for runoff and the greater the flow of water down the slope (Burkard & Kostaschuk, 1996; Ritter, 2012).

9.2 Sheet Erosion

According to Brundsen (1979), the concept of mass movement (alternatively referred to as mass wasting or landsliding) is the movement of material from higher to lower ground without the assistance of a fluid transporting agent, but rather the weight of a load and the slope’s shear strength. This means that the gravitational force resisting failure is outweighed by the gravitational force acting on the slope, which results in a large amount of movement of material.

Terzaghi (1960) identified two causes of mass movement:
1. External causes that increase the shear stress; and
2. Internal changes that decrease the shear resistance without changing the shear stress.

These causes of mass movements can further be explained by factors contributing to the increase in shear stress and decrease in shear resistance, many of which are experienced along the Lake Huron shoreline and can provide explanation for the occurrence of mass wasting within the study area.

Cooke and Doornkamp (1974) identified the factors leading to an increase in shear stress as the removal of underlying support, an increase in disturbing forces, transitory earth stresses and increased internal pressure. Removal of underlying support can be experienced through the process of undercutting by water, man-made cuts and excavations and weathering at the toe of the slope; an increase in disturbing forces is experienced through the presence of man-made pressures such as buildings, or the accumulation of water or snow through natural processes; transitory earth stresses are experienced through movement such as earthquakes; and increased
internal pressures include the buildup of pore water pressure in the soil (Cooke & Doornkamp, 1974). These factors are easily applicable to the situation occurring along the Lake Huron shoreline. Processes and events currently being experienced such as wave undercutting, human development and weathering at the toe of the slope, are all contributing negatively and ultimately resulting in mass movement of material.

Cooke and Doornkamp (1974) further identified the factors leading to a decrease in the sheer resistance of a slope. These factors include the materials that are present, the weathering changes and an increase in the pore water pressure. Materials whose beds decrease in shear strength as water content increases, such as clay, strongly contribute to a decrease in shear resistance of a slope. As clay is a prominent soil type found along the Lake Huron shoreline, it is known that mass movement is likely to occur. Other influences such as weathering and pore water pressure increase as a result of a high water table, often experienced after large amounts of precipitation, are factors that contribute greatly to a decrease in shear resistance. Ultimately, this leads to mass movement or mass wasting of the slope, a process that is seen all too frequently along the Lake Huron shoreline.

Understanding the process and causes of mass movement is crucial in developing recommendations for the future of the shoreline and shoreline management. While mass movement is a natural process, there are anthropogenic factors that contribute to the mass wasting of a slope. Understanding factors that can be controlled through regulation and best management practices can be beneficial in ensuring that property is not put at risk of experiencing mass movement and loss of land.
9.3 Splash Erosion

Soil erosion as a result of movement caused by rain, referred to as splash erosion, generally occurs during short, intense precipitation events (Ritter, 2012). As a result, the soil becomes saturated and the excess water that cannot be absorbed sits on surface, leading to a process known as saturated overland flow. Along the shoreline in Lake Huron, splash erosion and overland flow as a result of short, intense rainstorm events is seen frequently, especially in areas of the shoreline where little to no vegetation is present on the bluffs.

Both processes, known as splash erosion and sheet erosion, generally occur in section 3 of the cross section of the slope, as identified in Figure 7. Precipitation sits on the surface of the top of bank saturating the soil and eventually leading to large amounts of runoff and overland flow. These erosional processes begin in section 3 of the cross section and work their way down the slope through section 2 where they have the most detrimental effect on bluff failure. Development factors identified in section 9.5 such as impervious materials such as concrete and shingles decrease the amount of natural material that is available for water storage, greatly contributing to overland flow and runoff issues.
9.4 Gully Erosion

Gully erosion occurs commonly along the shores of the lower Great Lakes, especially in areas were shoreline bluffs hazards exist. The presence of gullies immediately adjacent to shoreline properties is a relatively new and concerning factor when considering suitability for development along the Lake Huron shoreline. Gullies are highly erosive due to a number of factors including the drainage basin or watershed area, the amount of precipitation as well as piping that occurs (Burkard & Kostaschuk, 1996). Other factors and processes including the removal of vegetation, surface runoff and channel outletting to Lake Huron also contribute negative connotations to shoreline development (Ontario Ministry of Natural Resource, 1981).

There are an estimated 200 gullies that have formed along the Lake Huron shoreline in Huron County, some of which developed through natural processes but others that have developed due to anthropogenic causes in the 1800s (Lake Huron Centre for Coastal Conservation, N.D.). The drainage basin, or watershed area, adjacent to the Lake Huron shoreline is largely comprised of active agricultural land. The agricultural community in Huron County is dominated by row crops, which are highly susceptible to soil erosion (Burkard & Kostaschuk, 1996). Runoff from these agricultural fields move water very quickly, often into exiting gullies for outlet to the Lake. Fast-moving water accelerates erosion, especially in areas where little vegetation exists to protect the slope. To further complicate the situation, the clay-rich soils that are present along the Lake Huron shoreline are much more prone to slope failures.

9.5 Development

Development pressures and ignorance from property owners pose a great risk to the
health of a shoreline and are large contributors to accelerated erosion along the Lake Huron shoreline. Modification of land, including the removal of vegetation and introduction of hard and impermeable surfaces increase the rate of runoff from the property and increase the load on an already unstable slope. While development is prohibited on the actual slope or bluff area shoreline, designated as Section 2 under the Maitland Valley Conservation Authority Shoreline Policies (2009), there are still many negative implications that constructing a dwelling has on a bluff.

The presence of a septic system or pump-out sewage system on a cottage property along the shoreline can pose issues related to shoreline erosion. The load that a septic system or pump-out sewage system puts on a slope, as well as the increased infiltration that occurs because of these systems puts further stress on the slope and increases the risk of rotational failure, slumping or landsliding, ultimately leading to an increased loss of property.

The modification of land adjacent to an erosion hazard can increase the recession rate of a slope and the rate of erosion greatly. Modifying a property by introducing hard surfaces such as driveways, patios and dwellings with impervious roofs all contribute to runoff processes during precipitation events that ultimately negatively affect the slope. These hard surfaces redirect water towards the slope and remove the amount of soil that is available to absorb water during a rainfall event.

There is a lack of knowledge amongst the public about erosion and natural hazards that often lead to misconception and misunderstanding (Scott & Parker, 1996). In a study completed by Daniel J. Scott and Paul K. Parker (1996) on shoreline hazards within the Great Lakes basin, it was demonstrated that 61% of cottage owners that experienced loss due to erosion were not aware of the risk to the property at the time of purchase. In order to combat this issue and ensure
that property owners are aware of the risk to their property, a solicitor’s inquiry can be requested from the Conservation Authority at the time of purchase. This document provides mapping of the property which includes information such as the location of the stable slope, stable top of bank and the 100 year erosion risk limit so that the potential purchaser is aware of the risks of owning a shoreline property.
10.0 Prevention Methods

According to the Ontario Ministry of Agriculture, Food & Rural Affairs (2001), the ultimate goal of government regulations is to protect the public interest from risk and hazard. The Conservation Authorities, municipalities and townships are responsible for creating and regulating their lands to reduce risk to people and loss of property. In order to do so successfully, provincial guidelines such as the Provincial Policy Statement and the Conservation Authorities Act as well as municipal guidelines such as Comprehensive Zoning By-Laws and Official Plans are created to ensure the goal of government regulation is met.

10.1 Provincial Policy Statement

Provincial Policy was created as a mechanism to prevent damage from natural hazards by controlling development. Its aim is to minimize risk to property, life, social disruption and environmental impacts by managing hazardous lands such as those that are susceptible to flooding and erosion (Byrne, 1998). The Provincial Policy Statement (2014) “sets the policy foundation for regulating the development and use of land” and “supports the provincial goal to enhance the quality of life” (p. 1). Further, it represents the minimum standards related to land-use planning and development by providing positive directives, limitations and prohibitions as well as enabling and supportive language.

Natural hazards are identified in the Provincial Policy Statement as an area of concern due to the potential to pose risk to residents. The policies that exist within the Provincial Policy Statement are very vague and general, suggesting that development shall generally be directed outside of hazardous areas and should not occur within the dynamic beach hazard, floodway and areas that would be inaccessible when flooding or erosion takes place (Ontario Ministry of
Municipal Affairs and Housing, 2005). Section 3.1.1 of the Provincial Policy Statement (2014) states:

3.1.1 Development shall general be directed to areas outside of:

a) Hazardous lands adjacent to the shorelines of the Great Lakes – St. Lawrence River System and large inland lakes which are impacted by flooding hazards, erosion hazards and/or dynamic beach hazards (p. 30).

Followed by:

3.1.2 Development and site alteration shall not be permitted within:

a) The dynamic beach hazard;

b) Defined portions of the flooding hazard along connecting channels;

c) Areas that would be rendered inaccessible to people and vehicles during times of flooding hazards, erosion hazards and/or dynamic beach hazards, unless it has been demonstrated that the site has safe access appropriate for the nature of the development and the natural hazard (p. 30).

These are vague guidelines that cannot be used on their own, but rather in conjunction with Maitland Valley Conservation Authority policies to determine acceptable locations for development along the shoreline. The policies set out in the Provincial Policy Statement for natural hazards provide the limitations and prohibitions in which the Maitland Valley Conservation Authority Shoreline Policies (2009) conform to.

10.2 Municipal Legislation & Land Use Control

Municipal legislation includes the County of Huron Official Plan, the Township of Ashfield-Colborne-Wawanosh Official Plan and the Township of Ashfield-Colborne-Wawanosh
Comprehensive Zoning By-law. It is through these documents that land-use control is governed within the watershed.

10.2.1 Huron County Official Plan

The Huron County Official Plan designates the shoreline as a settlement area which suggests that development is encouraged in this area. It does however suggest limited growth in these area and states that it is not intended to contain a full range of services (Huron County, 2013). The Official Plan states that “development shall be directed away from areas which pose a threat to public health and safety or property” to ensure safe setbacks from the hazard (Huron County, 2013, pp. 27). It is further stated that “natural hazards include existing hazards such as flooding hazards, erosion hazards, dynamic beach hazards, and potential hazards such as unstable soils, steep slopes, hazardous sites and hazardous lands” that address the issues currently affecting the shoreline (Huron County, 2013, pp. 27).

These documents provide guidelines for development and the future of the township and the county, but they both pose limitations in that i) amendments can be made and ii) these regulations are open to interpretation by the permitting agencies. It appears that applications can be made to fit into certain policies to push through development.

10.2.2 Ashfield-Colborne-Wawanosh Official Plan

The Township of Ashfield-Colborne-Wawanosh has its own Official Plan that was adopted in 2003 then updated in 2013. This Official Plan adopts basic principles of the Huron County Official Plan, however, the vision, goals and policies focus on the resources, capabilities and constraints specific to the Township of Ashfield-Colborne-Wawanosh.
Within the Township of Ashfield-Colborne-Wawanosh Official Plan, there is a specific section for Lakeshore and Recreation. According to the Ashfield-Colborne-Wawanosh Official Plan (2013), the goals that have been developed for lakeshore and recreational areas within the township are:

- To protect the natural features and functions of the lakeshore from incompatible development;
- To direct development to designated areas;
- To ensure clean drinking water and lake water for residents through the appropriate management of services and land use;
- To ensure appropriate and adequate services are provided along the lakeshore; and
- To direct development away from natural hazards such as the lake bank, dynamic beach and gullies (p. 5).

These goals are those that the Township of Ashfield-Colborne-Wawanosh finds to be the most important for lakeshore and recreational areas within their township. Through community participation, the residents of the Township were able to establish the future directions for the lakeshore and recreational areas.

Also within the Township of Ashfield-Colborne-Wawanosh Official Plan is a section dedicated to natural hazards and the lakeshore. According to this document, natural hazards include, but are not limited to, erosion, unstable slopes, lands adjacent to ravines, river valleys and streams, dynamic beaches and the Lake Huron shoreline (Ashfield-Colborne-Wawanosh, 2013). Within this section, there are four key goals that have been identified. They include:

- Development shall avoid areas of natural hazards. No new Lots are to be created in the Gully Erosion Potential area unless it has been demonstrated that the natural hazard has
been addressed through a municipally maintained erosion control system (Ashfield-Colborne-Wawanosh, 2013, p. 21);

- **Setbacks for buildings and structures from the top-of-bank and watercourses will be established in the Zoning By-law. Studies and mitigation measures may be required to overcome hazards to development. Erosion is, for the most part, a natural process which is essential to the ecological balance of large reaches of shoreline (Ashfield-Colborne-Wawanosh, 2013, p. 21);**

- **Land adjacent to the shoreline is a natural hazard area where the shoreline may be eroding or there is a risk of flooding, damage by storms and bluff failure. These and other natural processes must be considered when reviewing proposed development (Ashfield-Colborne-Wawanosh, 2013, p. 22); and**

- **New development will be directed away from hazard areas to protect: the natural processes and functions of the shoreline, residents and property. No development will be permitted on the lake bank, beach or beach vegetation area. Setbacks from steep slopes will be regulated by the Zoning By-law with reference to the 100-year erosion line and gully erosion potential area (Ashfield-Colborne-Wawanosh, 2013, p. 22).**

These goals are interesting when reviewing policies and regulation that govern shoreline development. It is stated that “erosion is, for the most part, a natural process” (Ashfield-Colborne-Wawanosh, 2013, p. 21). While this is a true statement, there is no mention to the anthropogenic influences that development may have on this process, but rather only the influence that erosion may have on people and the structures on their properties. Further, it is stated that “no development will be permitted on the lake bank, beach or beach vegetation area”
(p. 22) however, many of the issues that are present along the shoreline are occurring in the areas of interference adjacent to the hazard which is on the lake bank and in the beach area.

While the Township of Ashfield-Colborne-Wawanosh Official Plan has set directives for the future of the lakeshore and natural hazard lands, the goals are vague and do not reflect the current state of the shoreline within the township. It is necessary that there is a clear understanding of the current state of the shoreline within the Official Plan to set out goals and objectives that will not only guide future development, but also attempt to mitigate issues surrounding existing development in these locations.

10.2.3 Ashfield-Colborne-Wawanosh Comprehensive Zoning By-law

The Township of Ashfield-Colborne-Wawanosh Comprehensive Zoning By-Law was passed on June 3rd, 2008 under section 34 of the Planning Act (Ashfield-Colborne-Wawanosh, 2008). It is comprised of both text and maps which implements the by-laws associated with the Township of Ashfield-Colborne-Wawanosh Official Plan that was adopted by Township Council in 2003. It provides land-use by-laws and states specific requirements and exceptions for development within designated lands.

The Lake Huron shoreline within the Township of Ashfield-Colborne-Wawanosh has three different zones: Natural Environment (NE1), Lakeshore Residential – Seasonal (LR1), and Lakeshore Residential – Year Round (LR2). Each of these zones have different permitted uses, permitted structures and special provisions specific to each location. The Zoning By-law also provides guidelines for minimum lot size and lot frontage, however property owners can apply for relief or amendments to these by-laws for extenuating circumstances. In all instances along the shoreline, the Maitland Valley Conservation Authority is circulated and provides comments.
on the appropriateness of the amendment and determines whether or not the application also conforms to MVCA policies.

There is a holding zone designation placed on lots along the shoreline that are currently undeveloped. This ensures that all the necessary permits and studies are completed prior to issuance of a building permit from the township (Ashfield Colborne Wawanosh, 2008). In order to receive permissions to develop a lot in a holding zone, permissions need to be received from the Conservation Authority and the Township. The Township will not issue a building permit until approval has been given by the Conservation Authority, stating that development conforms with shoreline development policies.

It is generally suggested in Huron County that development should occur in a way that meets policies but also takes a stewardship approach to include Best Management Practices and mitigate negative implications that exist because of development and recreational uses along the shoreline. It is important for the Township of Ashfield-Colborne-Wawanosh to continue to explore options related to development in the Official Plan and Comprehensive Zoning By-law documents. Having a holding designation on vacant lots is a good way for the County, Township and Conservation Authority to ensure that all necessary studies are completed prior to the issuance of final approval for development. This is a step in the right direction, however it does seem that development is rarely refused. Perhaps the setbacks and guidelines that are identified in these documents should provide more stringent rules that do not allow for as much interpretation.

10.3 Ontario Ministry of Natural Resources

The Ontario Ministry of Natural Resources provides advice to local authorities for implementing three important pieces of provincial legislation: the Conservation Authorities Act,
the Lakes and Rivers Improvement Act and the Public Lands Act. These pieces of legislation are important in the management, protection and preservation of natural resource management, natural features, and land use planning in Ontario.

10.3.1 Conservation Authorities Act

In December 1986, the Ontario Ministry of Natural Resources (OMNR) designated Conservation Authorities as the implementing agency for delivering shoreline management programs for the Great Lakes (F.J. Reinders and Associates, 1989). The purpose of which, was to address issues that were occurring along these shorelines with respect to prevention, protection and emergency response measures. With specific regards to shoreline erosion, the purpose of a shoreline management plan is to minimize property damage and risk to life from the hazard as well as to ensure that shoreline development is planned in a way that addresses erosion hazards through public and private management (F.J. Reinders and Associates, 1989).

The Maitland Valley Conservation Authority is responsible for regulating all development and activities from the edge of the water to the 100 year erosion risk limit under Ontario Regulation 164/06 Development, Interference with Wetlands & Alterations to Shorelines & Watercourses Regulation. Specifically within this regulation is Section 3.4, Maitland Valley Conservation Authority Shoreline Policies, updated in 2012. These policies reflect general conditions of shoreline development, development that is permitted and development that is prohibited along the shoreline.

This regulation ensures safe development and minimizes the potential for loss of property damage and harm to life by determining setbacks for development. According to the Shoreline Policies (2012) development is not permitted within the wave uprush limit, may be permitted within the dynamic beach, is not permitted within the bluff hazard and may be permitted at the
top of slope. The policies reflect minimum requirements for development; however the setbacks identified tend to become the go ahead line for development. For example, the setback of 15 metres from stable top of bank is not a conservative amount of space given the current recession rates and the large mass-wasting processes that are being seen as a result of intense storms. As climate changes and there is an increase in frequency and duration of storms, it is likely that mass-wasting will occur more frequently and recession rates will likely rise.

In order to develop in areas of interference adjacent to the shoreline, a phased geotechnical assessment may be required by the Conservation Authority. This assessment is required when development is proposed within a location of the shoreline that may be at risk of failure. It should, however, be required for any development within the area of interference adjacent to a slope.

There are two different phases of geotechnical assessments that exist. The first, a Phase I investigation is a non-intrusive investigation performed by a geotechnical engineer that assesses the stability of the specific slope in question (Maitland Valley Conservation Authority, 2012). This investigation is done by reviewing information such as mapping, geotechnical reports and other technical information that is available; a site visit to identify any indications of slope instability or seepage as well as recommendations for siting and drainage. There is no drilling or test pits that are completed during this investigation. If the results of this investigation are satisfactory to the Conservation Authority, no further studies are required. However, if the results of the investigation prove to be unsatisfactory, a Phase II geotechnical investigation will be required. The Phase II geotechnical investigation is a detailed investigation that will determine recommendations for structural engineering, major alterations or any slope stabilization work (Maitland Valley Conservation Authority, 2012). During a Phase II investigation, test pits and
further technical studies may be required to determine whether or not the slope is structurally sound for the development proposal.

Geotechnical assessments tend not to be required as often as they should be. Within the Maitland Valley Conservation Authority policies, it is suggested that a geotechnical assessment be required for any applications within section 2 (the bluff) of the slope, or should the Authority feel that there is an increased risk of failure (Maitland Valley Conservation Authority, 2009). As a minimum requirement, Phase I geotechnical assessments should be required prior to any development or redevelopment within the areas of interference adjacent to the slope. This will ensure that the slope is stable enough to support the development proposal and the safety of the landowners and property is not jeopardized.

10.3.2 Lakes and Rivers Improvement Act

The Lakes and Rivers Improvement Act is a piece of Provincial Legislation in Ontario that allows the Ministry of Natural Resources to provide advice and guidance for the management, protection and preservation of watercourses and water bodies in Ontario with the same legislative authority as the Conservation Authorities Act. According to the Lakes and Rivers Improvement Act Administrative Guide (2011), the purpose of the Act is to provide for:

- The management, protection, preservation and use of the waters of the lakes and rivers of Ontario and the land under them;
- The protection and equitable exercise of public rights in or over the waters of the lakes and rivers of Ontario;
- The protection of the interests of riparian owners;
- The management, perpetuation and use of the fish, wildlife, and other natural resources dependent on the lakes and rivers;
e. The protection of the natural amenities of the lakes and rivers and their shores and banks; and

f. The protection of persons and of property by ensuring that dams are suitably located, constructed, operated and maintained and are of an appropriate nature with regard to the purposes of clauses (a) to (e) (p.1).

Revetments, embankments and retaining walls are considered to be channelization methods under the Lakes and Rivers Improvement Act (Ontario Ministry of Natural Resources, 2011). However, it is stated that channelization within the Great Lakes basin will not require approval under the Lakes and Rivers Improvement Act for channelization works, but the projects may be subject to the Public Lands Act.

10.3.3 Public Lands Act

Crown land in Ontario is managed under the Public Lands Act and administered by the Ontario Ministry of Natural Resources for land use planning, land management and development on Crown land. Under the Public Lands Act 1990, Part IV Construction of Dams, is applicable for the purpose of this research project. According to the Public Lands Act (1990), a dam includes structures such as any channel, diversion or groyne, among others, for the control and regulation of water. As such, permission may be required by the Ontario Ministry of Natural Resources for the implementation of structural protection works on crown land within the study area.
11.0 Protection Methods

Protection methods can be described as the implementation of capital works and structures for prevention purposes, occurring as either structural or non-structural methods. Generally, non-structural methods are less expensive works and are more preferred, but are unable to make a significant impact in highly erosive hazard lands. Non-structural methods include the use of vegetation and dune systems for shoreline management. Alternatively, structural methods such as revetments, groynes and breakwaters are more expensive, permanent structures that are used to protect the shoreline from hazards such as flooding and erosion.

The use of protection methods are one alternative to shoreline management by physically protecting the erosion hazard. These works are seen often throughout the Great Lakes basin due to the success of reducing risk associated with slope hazards. Structural and non-structural protection methods will be further discussed as opportunities to protect the shoreline within the study area.

11.1 Structural Methods

Structural methods are generally the least preferred protection method as they are more expensive structures to build and maintain and overall, not generally aesthetically pleasing. Structural methods are capital works and permanent structures that are built to protect the shoreline from hazards such as flooding and erosion. These structures are expensive to build, expensive to maintain and may prompt issues relating to deposition areas upshore. The following structural methods have been identified as successful structural methods to minimize the impact that the Lake Huron water levels and wave uprush have on the toe of the slope.

Typically, structures are designed to have a 100 year life expectancy which is based on the structure’s material condition and quality, the quality of the construction and the location of
the structure (Shoreplan Engineering Ltd., 2010). Some materials are better able to withstand the impact that water, wave action, wind and weathering has on a structure. By ensuring quality materials are used, this will limit the requirement for maintenance on a structure. An experienced, well-informed engineer will be aware of the proper materials to use when designing and constructing a structure such as a revetment, groyne or breakwater.

Maintenance of protective shoreline structures can occur in one of two ways: on-going preventative maintenance and repair of a structure or site specific repair that may occur to fix damage received by a severe storm. On-going preventative maintenance occurs on a regular basis to replace materials that may be damaged or not performing as required. Flank protection for adjacent properties at the end segments of structural works may require on-going maintenance as time goes on. Site specific repair will often occur after a severe storm even that damages part of or the entire structure. While these structures are designed to withstand a 100-year event, situations still arise where maintenance is required.

Each of the following structural methods will be discussed as they are the most ideal structural protection methods for shoreline management along the bluffs of the Lake Huron shoreline. The greatest type of erosion that the study area is facing is toe erosion as a result of wave action and wave energy at the toe of the slope. As identified in Figure 6, section 1 of the slope cross section from the lake level to the toe of the bluff is the section of the bluff that will most benefit from the protection methods identified below. By implementing structural methods such as revetments, groynes and breakwaters, the toe of the slope is protected from scouring and toe erosion as a result of wave action and high water levels.
11.1.1 Revetments

On the shorelines of the Great Lakes, revetments are considered to be the most successful type of structural works (Shoreplan Engineering Ltd., 2010). Revetments are engineered shoreline protection structures that protect embankments from wave action, precipitation, overland flow and stream or river currents (U.S. Department of Transportation, 2011). As seen in Figure 8, revetments are sloped structures that extend from the bed of a body of water to the stable top of slope, with an erosion resistant face such as armour stone, concrete blocks and gabion baskets. It is suggested that these materials will absorb wave energy, ultimately protecting the bluff from scouring and erosion at the toe of the slope.

According to the Lake Erie Shoreline Management Plan developed by Shoreplan Engineering Limited (2010), to be successful, a revetment must be able to meet the following five criteria:

a. Stability and durability of the armoured layer;

b. Over top scour protection;

c. Toe scour protection;
d. Flank protection; and

e. No significant negative impact on coastal processes.

By incorporating these criteria into the design and implementation of a revetment, the structural works will successfully protect the shoreline from further destruction.

Ensuring the structure is designed to withstand ice and storm events is an important component of a successful structure. When designing revetments, it is important to use the proper size armour stone for protection. This will ensure that the design of the revetment is optimal for absorbing wave energy and will have the ability to survive large storms. Hudson’s equation is used to determine the size of armour stone that should be used by incorporating the slope and the wave height that the revetment is being designed for (U.S. Department of Transportation, 2011). Ideally, a revetment would be designed to last 100 years, but it is unlikely that a structure could last that amount of time without maintenance (Shoreplan Engineering Ltd., 2010).

Overtop scour protection and toe scour protection are two important components of a successful revetment. Water that is able to reach the top of the structure and scour the slope behind it is the most common reason for failure of a structure (Shoreplan Engineering Ltd., 2010). It is important to construct a splash apron at the top of the structure and extend back five to ten feet beyond the slope (U.S. Department of Transportation, 2011). This will ensure that in most cases, excluding extreme events, the structure will experience minimal damage. Toe scour protection is important because it will ensure that the soil or fill beneath the armoured face is not exposed to wave action. Exposed soil at the toe of the structure can be detrimental to the stability of the structure and the stability of the slope it is protecting.
Flank protection means that the end segments of a revetment need to be protected because they are the most vulnerable part of the structure (Shoreplan Engineering Ltd., 2010). If the end segments of a revetment are not protected properly, water has easy access to the soil and fill layer beneath the armoured face which will ultimately lead to failure. It is suggested that revetments be constructed on many adjacent properties as one large segment of protection to avoid erosion issues at the end segments. If two adjacent properties are experiencing erosion and a revetment is installed on one property but not the other, it is likely that the unprotected slope will see an accelerated increase in failure on their property. The final criteria to be addressed when designing and implementing a revetment for shoreline protection works is that there must not be a negative impact on coastal processes. This is important to ensure that the natural hydrological function of the lake will not be affected. In most cases, the engineered design of the revetment ensures that this will not be an issue.

11.1.2 Groynes

A groyne is a type of structural method for the protection of a shoreline used to hold material in place and minimize deposition and movement along the shoreline. Groynes are beneficial to shoreline health and management for a number of reasons. According to Shoreplan Engineering Limited (2010), groynes are used to build up beaches on eroding shorelines, hold material in place where erosion would otherwise take place and increase the size of existing beach systems. Groynes are long narrow structures that extend perpendicular to the shoreline, often made of wood, concrete or rock piles (van Rijn, 2011). Groynes are used either individually or in groups known as groyne fields, as seen in Figure 9. The benefit to a groyne field is that it is more effective in working to protect against erosion than is one groyne on its own.
Groynes are relatively attractive form of structural protection for the shoreline because of the increased aesthetic quality it provides and the increase in property value that comes along with that. Groynes trap sand which increases the amount of material present in a beach location (Shoreplan Engineering Ltd., 2010). This creates larger beach areas that are more suitable for recreation purposes and more widely received by the public (Jennings, 2004). Potential property owners will see more value in a property that has a large beach than one that does not and this will lead to an overall increase in the value of a property from an aesthetic point of view. Access to water and an aesthetically pleasing property are often of more concern to property owners than the risk of flooding or erosion hazards on their properties.

In the case of the Lake Huron shoreline, it is more effective to implement a system of groynes in a groyne field as opposed to one individual groyne because of tendencies of sediment transport and deposition. Along the shores of Lake Huron, deposition and sediment transportation are known issues contributing to erosion and slope failure. If only one groyne is installed, it may help protect one area against erosion, but will negatively impact other areas of the shoreline. By implementing a groyne field, it is an effective way to manage and control the direction of sediment transport and location of deposition by moving material to a chosen area. A
carefully engineered groyne field system would be beneficial in managing erosion as a result of material transport and deposition along the shoreline.

11.1.3 Breakwaters

A breakwater is a structure erected in the water, adjacent to the shoreline that acts as a shield, minimizing the impact that waves and wave energy have on an eroding slope (Shoreplan Engineering Ltd., 2010; van Rijn, 2011). Breakwaters can be constructed by either being fixed to the lake bed or floating off-shore, however the latter is less preferred for the Lake Huron shoreline due to the geography and geometry of the shoreline. Fixed breakwaters would be the most ideal of the two for this study area, as they would do the best job minimizing the wave energy that reaches shore. Fixed breakwaters require a similar engineered design as revetments do to ensure that they are structurally sound and do not experience over top scouring or toe scouring (Shoreplan Engineering Ltd., 2010).

A breakwater that is fully submerged below the surface is not ideal for some shorelines, such as the Lake Huron shoreline, because it will not stop or reduce erosion during storms (van Rijn, 2011). In conditions such as these, waves will simply pass over the structure and have open access to the toe of the bluff. Since toe erosion as a function of wave energy is a large issue along the Lake Huron shoreline, partially submerged breakwaters become a possible method for reducing erosion along the shoreline.

11.2 Non-Structural Methods

Non-structural methods for shoreline protection include “soft” works such as planting vegetation to stabilize slope and slow runoff as well as maintaining dune systems. Generally,
non-structural methods are preferred as they are less expensive and more aesthetically pleasing, but also do not work as well the structural methods previously discussed. A benefit of non-structural protection methods is that it complements natural shoreline processes and promotes increased vegetation cover and habitat (Shoreplan Engineering Ltd., 2010). A constraint associated with non-structural protection methods is that they are not generally viable in as many locations. Some bluff areas and portions of the shoreline are unable to successfully manage non-structural protection methods, leaving structural protection as the only other option.

Non-structural methods are a preferred method of shoreline protection works by property owners as they are more cost-effective and easier to maintain on a private property level.

11.2.1 Vegetation

While structural protection methods are considered to be more effective in some areas of the shoreline, it is still considered a best management practice to increase vegetation on bare slopes. Vegetation is an important factor that strongly contributes to the strength of an eroding slope. The more vegetated a slope is, the stronger it will be and the lower the chance of failure. Although vegetation cannot protect against wave uprush at the toe of the slope or stabilize a slope already experiencing mass wasting, it is beneficial for strengthening a bare slope by binding the soil to increase its resistance to erosion and slope failure (Lake Huron Centre for Coastal Conservation, N.D.b). Along the Lake Huron shoreline and in other recreational communities, it is evident that property owners are looking for the view. Removing vegetation, such as trees, shrubs and grasses, from the slope in order to have a better view of the water can be detrimental to the health of the slope. Vegetation is one of the most effective types of protective works that can be used along the shoreline because of its ability to slow overland flow
and sediment transport as well as stabilize a slope (Byrne, 1998). It is widely noted throughout the literature that a factor that contributes most widely amongst varying types of erosion and failure is the absence of vegetation from a slope.

Plant cover protects the soil from run off by slowing down the movement of water and providing extra time for the surface water to infiltrate the soil and slow down the process of erosion (Ritter, 2012). The type of vegetation present on a slope can be a good indicator of slope strength. The roots from grasses, trees and shrubs strengthen the slope providing a stabilizing mechanism against slope failure. The type of vegetation present on a slope stabilizes the slope through the root system. It should be noted that not all forms of vegetation are beneficial for slope stability. Various types of vegetation draw water down into the root system which is actually detrimental to slope stability because of the increased amount of water that permeates the soil.

Vegetation that provides cover year round as opposed to seasonally are better for the health of the slope because they do not leave the slope bare during certain seasons and are able to slow the movement of water (Ritter, 2012). This is an important consideration as often some of the highest intensity runoff events occur in the spring when snow is melting and moving down the slope. It is noted that along the Lake Huron shoreline, the peak annual discharge and large sediment load in streams occurs during the spring melt (Burkard & Kostaschuk, 1996). This is of concern, especially for those slopes that are not dominated by vegetation species that cover the slope year round. Activities, such as recreational activities that occur in conjunction with recreational development, that may damage or destroy vegetation, can initiate a process that can increase and intensify the erosional processes occurring along the shoreline (Peach, 2006).
12.0 Recommendations

As a result of the research that was conducted, recommendations have been made to guide the future of shoreline development and management along the Lake Huron shoreline in the Maitland Valley Conservation Authority watershed in Huron County. These recommendations have been developed through considerations relating to the geology and characteristics of the shoreline in the study area, current provincial and municipal policies and information provided from working professionals through a questionnaire and key informant interviews.

It is suggested that the Conservation Authority be the primary contact and implementing agency when dealing with shoreline development and management. Maitland Valley Conservation Authority is a small Conservation Authority that does possess financial stability to take on new initiatives without the support of Huron County.

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<td>11.0</td>
</tr>
<tr>
<td>6.</td>
<td>10.3.1</td>
</tr>
</tbody>
</table>

Table 2. Recommendation referral locations.

The following recommendations are based on the information that was provided throughout this research project:

1. The Conservation Authority shall continue to act as the primary agency involved in shoreline development and management along the Lake Huron shoreline through enforcement of policies and regulations for prevention.

Conservation Authorities are quasi-governmental organizations that have regulatory
power surrounding natural and hazardous features but are also an agency focused on implementing stewardship projects and Best Management Practices relating to these features. As such, the Conservation Authority is in a better suited position than the Township or Municipality to be the primary agency involved in shoreline management. The Conservation Authority tends to have a better working relationship with property owners than the municipality due to the regulatory stature of the county.

The Conservation Authority follows policies and regulations as set out by the Conservation Authorities act to ensure development occurs away from the hazard and in a way that protects life and property from damage. While the municipality ensures that development conform to the Provincial Policy Statement and the Planning Act, its involvement relating directly to development in or adjacent to hazard lands is minimal.

2. Programs to encourage Best Management Practices for property owners along the Lake Huron shoreline shall be implemented by the Conservation Authority in partnership with the Municipality.

Lack of knowledge and education surrounding shoreline processes can be considered a leading factor of contributions to bluff erosion. Ignorance towards the hazard and lack of consideration for the pressures development may put on a slope can lead to negative outcomes.

As part of an outreach program, the Conservation Authority, in partnership with the Municipality, should take on a stewardship and education approach to informing the property owners of the hazards that exist, why they exist and what can be done to minimize the negative impacts that erosion has on a property. Workshops provide the opportunity for professionals to explain and educate the public on important issues, but also allows for the public to be able to
ask questions and establish rapport with professionals at the Municipality and the Conservation Authority. Establishing and maintaining rapport and a good working relationship with property owners establishes respect among professionals & regulatory authorities and property owners.

Efforts should not only be focused on new development within the study area but also on existing development in an effort to mitigate the issues that currently exist and minimize the impact that existing development may have on the hazard in the future. Pro-active approaches to minimizing risk in both situations is important for the overall health of the hazard in both the near and distant future.

3. Programs to encourage Best Management Practices for adjacent property owners

Farming agricultural land shall be implemented by the Conservation Authority in partnership with the Municipality.

Property owners adjacent to the shoreline are not the only one whose land-use activities have negative impacts on the shoreline. As previously discussed, agricultural land use is the primary land-use on lands adjacent to the shoreline. Behind these cottages and recreational dwellings lay hundreds of acres of prime agricultural land. Best Management Practices and stewardship initiatives should also be the responsibility of those whose agricultural practices have an impact on bluff and gully erosion.

Programs such as brochures, public meetings and workshops are ideal for these purposes. Incentives should be made available to property owners who initiate Best Management Practices and stewardship initiatives on their properties, such as planting a buffer at the edge of the property line or constructing berms to keep water from running over the slope.
4. Incentives shall be offered to property owners along the shoreline to undertake structural and/or non-structural works on private property, subject to input and approval from the Conservation Authority and the Municipality.

Relationships with property owners are perhaps the most important relationship to be considered when dealing with a natural hazard such as erosion. Although erosion is an unpredictable natural hazard, there are many precautions that can take place in order to minimize the opportunity for failure on private property. Both structural and non-structural protection works can be costly, one of the biggest reasons that these works are not implemented regularly. Beyond the initial cost of material and construction, maintenance of protection works also requires financial resources for years to come.

As a result, incentives should be offered to property owners that wish to undertake protection works on their properties, subject to input and approval from the Conservation Authority. Incentives such as discounted rates from the Conservation Authority and the Municipality for permits or financial assistance purchasing materials for structural works would encourage property owners to partake in protecting their own properties.

The Grand River Conservation Authority runs a successful program called the Rural Water Quality Program that promotes implementation of Best Management Practices by rural landowners on their own properties. In order to encourage participation among property owners, applicants receive a discounted rate on permit applications and are able to apply for funding through the Conservation Authority as well as through the local Municipality and provincial government (Grand River Conservation Authority, 2014).

A similar program should be implemented through the Maitland Valley Conservation Authority to promote Best Management Practices and the implementation of structural and non-
structural works on private property. By providing incentives to property owners, this encourages them to undertake protection works and ownership over protecting the well-being and safety of their own property. Other incentives that could be explored include tax breaks from the municipality to assist in off-setting costs of protection works.

Of the structural protection methods that were identified in this research project, revetments are recommended to be the most suitable for the study area. Erosion as a result of wave action and wave energy at the toe of the slope can be minimized through the implementation of structural works.

5. Setbacks identified within the Ashfield-Colborne-Wawanosh Comprehensive Zoning By-law and the Maitland Valley Conservation Authority Shoreline Policies should be enforced as minimum standards.

The setbacks that have been identified in the Township Comprehensive Zoning By-law and the Maitland Valley Conservation Authority Shoreline Policies should be considered minimum standards, not the closest development can occur in relation to the hazard. Encouraging development to take place a distance away from the hazard is beneficial for both the development and the stability of the slope. The Township and the Conservation Authority should be approving development at the minimum standard only in situations where there is not enough room for larger setbacks.

6. Phased geotechnical assessments should be required for all applications for development, for both existing and new development, anywhere within the 100-year erosion risk limit.
Regardless of the location of development, if it is within the 100-year erosion risk limit, a Phase I geotechnical investigation should be required as a minimum standard. Any development that is occurring within the erosion risk limit has the potential to be affected by the hazard or have a negative impact on the hazard. By completing a Phase I geotechnical investigation as a minimum standard for any new or existing development would alleviate concerns for slope failure. This, associated with an owner acknowledgement of the risks of developing within the area of interference adjacent to the hazard would protect the Township and Conservation Authority from liability associated with damage that may occur as a result of slope failure, but would also inform and educate the property owner about the potential risks associated with having a lakeshore property.
13.0 Summary & Next Steps

The goals and objectives of this research project were achieved through the development of recommendations that will assist in guiding shoreline development and management within the Maitland Valley Conservation Authority jurisdiction along Lake Huron. These recommendations are based upon the information that was gathered in the literature review, the responses that were received in the questionnaire and the information and experiences that were offered through the key informant interviews. The protection and prevention methods that were identified are considered to be the most appropriate methods for the specific study area. Through the implementation of both structural and non-structural protection methods and proper land-use planning and setbacks, the negative impacts associated with development in the areas of interference adjacent to hazard lands can be minimized.

The next steps that should be taken by Maitland Valley Conservation Authority is the formulation of a Shoreline Management Plan that specifically details and guides development within the watershed jurisdiction for the future. Shoreline Management Plans have proven to be successful in guiding development and the formulation of policies within other Conservation Authority jurisdictions within the Great Lakes shoreline. Within this Shoreline Management Plan, it should encourage tighter relationships between the Conservation Authority, the Township and County to create education programs to assist and promote best management practices to both landowners on the shoreline and landowners in the adjacent agricultural land.
14.0 Glossary

**Best Management Practices**: A practical and/or effective means of achieving protective works on a property to protect loss of life and property damage, while enhancing the natural features.

**Bluff**: A steep slope of unconsolidated sediment that exists along the shoreline due to the presence of active erosion.

**Development**: Construction or reconstruction of dwellings, additions to existing dwellings or residential accessory structures associated with a house or cottage.

**Erosion**: A reduction in shoreland by natural processes.

**Glacial Till**: Clay, sand and gravel sediment, known as St. Joseph’s Till along Lake Huron.

**Great Lakes Basin**: The geographic location in Southern Ontario with Lake Ontario & Lake Erie to the east and Lake Huron & Lake Michigan to the west.

**Gully Erosion**: An erosional process that takes place in narrow channels, cut into the bluff.

**Groyne**: Shore protection structure to trap sand and protect the shoreline from erosion by making a beach.

**Mass-wasting**: The movement of a large amount of land or sediment down slope due to erosional processes. Mass-wasting most often occurs after high intensity rain events where a large amount of precipitation has a negative effect on the slope.

**Natural Hazard**: A naturally occurring process that has the potential to be damaging to property or cause loss of life (ie. erosion).
**Nearshore:** The area of the shoreline extending towards the lake formed primarily by wave action.

**One Hundred Year Erosion Risk Limit:** The average annual recession rate extended 100 years from the eroding slope of the bluff.

**Recession:** A retreat of the shoreline by natural shore processes.

**Silt:** Inorganic material carried in suspension or deposited by currents.

**Slump:** Failure of large sections of a bluff, often caused by waterlogged slopes.

**Suitability:** The appropriateness of an action in a certain location (ie. the appropriateness of development in a highly erosive location along the shoreline).

**Toe Erosion:** Erosion that occurs at the toe of the bluff as a result of the continuous removal of material by waves and water actions.

**Uprush:** The movement of water onto the beach following the break of a wave.

**Vulnerability:** The possibility of negative implications (ie. the shoreline is a vulnerable ecosystem due to the potential for erosion).

**Wave undercutting:** The process in which waves damage the base (or toe) of a slope, weakening the slope at its base.
15.0 Appendices

Appendix A: Correspondence to Professionals for Involvement in Project

Good Afternoon,

My name is Mollie Kuchma and I am a Master of Science (Planning) Candidate at the University of Guelph, I am looking for assistance in completing a short questionnaire on factors associated with shoreline erosion in areas of residential and seasonal development. Please forward this survey to any professionals within your organization that may have experience working with development in erosive areas that would be very greatly appreciated.

The link to the questionnaire is below. Should you have any questions or require any further clarification, please do not hesitate to contact me. Thank you for your time and participation in this survey.

http://www.surveymonkey.com/s/3GR38G2

Yours truly,

Mollie Kuchma
MSc (Planning) Candidate
Rural Planning & Development
University of Guelph
mkuchma@uoguelph.ca
(519)277-9694
Appendix B: Questionnaire Questions

Name:
Company:
Position
Email Address:
Phone Number:
Are you willing to be contacted for an interview?
Preferred method of contact:

The following criteria have been identified as important factors associated with development (seasonal, recreation and residential) in areas with active shoreline erosion. Based on your professional experience working with shoreline development, please rank the following criteria (from most important (1) to least important (10) factors) as factors to consider when dealing with shoreline development and management.

☐ Percentage of Vegetation Cover on Slope
☐ Vegetation Type Present on Slope
☐ Proximity of Dwelling to Stable Slope Allowance
☐ Recession Rate of Slope
☐ Soil Type & Composition
☐ Presence of Septic or Pump-out Sewage System on Property
☐ Slope Angle
☐ Property Size
☐ Presence of Gullies
☐ Distance from Dwelling to 100 Year Erosion Risk Limit

Please provide a brief explanation of your choice of ranking, or alternatively, provide feedback on other factors that are important to consider when considering development on erosive shorelines.
## Appendix C: List of Questionnaire Participants

<table>
<thead>
<tr>
<th>Position</th>
<th>Organization</th>
<th>Date Completed</th>
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<tbody>
<tr>
<td>1 Professor of Civil Engineering</td>
<td>Queen’s University</td>
<td>December 9, 2013</td>
</tr>
<tr>
<td>2 Water Resources Engineer</td>
<td>Cataraqui Region Conservation Authority</td>
<td>December 9, 2013</td>
</tr>
<tr>
<td>3 Manager, Watershed Science &amp; Services</td>
<td>Lower Trent Conservation Authority</td>
<td>November 11, 2013</td>
</tr>
<tr>
<td>4 Resource Planner</td>
<td>Grand River Conservation Authority</td>
<td>November 6, 2013</td>
</tr>
<tr>
<td>5 Junior Planner</td>
<td>Municipality of Chatham-Kent</td>
<td>November 4, 2013</td>
</tr>
<tr>
<td>6 Senior Planner</td>
<td>Halton Region</td>
<td>October 30, 2013</td>
</tr>
<tr>
<td>7 Coordinator, Regulations Program</td>
<td>Halton Region Conservation Authority</td>
<td>October 30, 2013</td>
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<tr>
<td>8 Planner</td>
<td>County of Lambton Planning &amp; Development</td>
<td>October 29, 2013</td>
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<tr>
<td>9 Ecology &amp; Stewardship Specialist</td>
<td>Lower Trent Conservation Authority</td>
<td>October 17, 2013</td>
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<td>10 Regulations Officer</td>
<td>Quinte Conservation</td>
<td>October 15, 2013</td>
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<tr>
<td>11 Planning Coordinator</td>
<td>Catfish Creek Conservation Authority</td>
<td>October 10, 2013</td>
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<tr>
<td>12 Biologist</td>
<td>Cataraqui Region Conservation Authority</td>
<td>October 7, 2013</td>
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<tr>
<td>13 Project Engineer</td>
<td>R.J. Burnside &amp; Associates Ltd.</td>
<td>October 3, 2013</td>
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<td>14 Team Leader</td>
<td>LVM Inc.</td>
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<tr>
<td>15 Senior Engineer</td>
<td>B.M. Ross &amp; Associates</td>
<td>October 3, 2013</td>
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<tr>
<td>16 Supervisor of Water and Planning</td>
<td>Ausable Bayfield Conservation Authority</td>
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<td>17 Regulations Assistant</td>
<td>Crowe Valley Conservation Authority</td>
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<tr>
<td>18 Environmental Planner/Regulations Officer</td>
<td>St. Clair Region Conservation Authority</td>
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<tr>
<td>19 Coordinator</td>
<td>Huron Stewardship Council</td>
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<tr>
<td>20 Resource Technician</td>
<td>Lower Thames Valley Conservation Authority</td>
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<tr>
<td>21 Supervisor, Erosion Planning and Monitoring</td>
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<td>23 Environmental Planner/Regulations Officer</td>
<td>Long Point Region Conservation Authority</td>
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Appendix D: Key Informant Interview Questions

1. When you think of development of recreational and year-round homes along erosive slopes, what is your initial though? Do you consider this to be good planning practice?

2. Who are the majority stakeholders involved in shoreline development in erosive areas? What are their concerns?

3. Do you feel that in your current position you have the ability to influence decisions or do you feel bound by regulation? What regulatory bodies are you governed by?

4. What regulatory changes would you, if possible, make to current policies involved in shoreline development?

5. Do you feel that current regulations are too lenient or too strict? Why?

6. Which approach do you feel is more effective in reducing the anthropogenic influences on erosion hazards: stewardship and best management practices or regulation?

7. In a hypothetical situation, if both a municipality and conservation authority permit development along the shoreline and the safety of the home is compromised due to safety concerns from the slope, who becomes liable? Do you feel that this situation will become increasingly common as time goes on? Are there opportunities for mitigation in situations such as these?

8. Any other comments or suggestions?
## Appendix E: List of Key Informant Interview Participants

<table>
<thead>
<tr>
<th>Position</th>
<th>Organization</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Professor</td>
<td>University of Toledo</td>
</tr>
<tr>
<td>2</td>
<td>Junior Planner</td>
<td>Municipality of Chatham-Kent</td>
</tr>
<tr>
<td>3</td>
<td>Supervisor, Erosion Planning &amp; Monitoring</td>
<td>Toronto Region Conservation Authority</td>
</tr>
<tr>
<td>4</td>
<td>Resource Technician</td>
<td>Lower Thames Valley Conservation Authority</td>
</tr>
<tr>
<td>5</td>
<td>Biologist</td>
<td>Cataraqui Region Conservation Authority</td>
</tr>
<tr>
<td>6</td>
<td>Environmental Planner/Regulations Officer</td>
<td>Long Point Region Conservation Authority</td>
</tr>
</tbody>
</table>
16.0 References


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