Huron County Extreme Lake Levels Integrated Assessment
Phase I Report – May 3, 2016

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EXECUTIVE SUMMARY

The past decades have seen unprecedented fluctuation in Great Lakes water levels, with significant economic, environmental, and social impacts resulting from extreme low water levels as well as the most recent flooding and high water situation. Ontario municipalities along the Great Lakes shorelines have experienced the full range of impacts of extreme water levels, leading to research and policy work on adaptive management, disaster relief, and planning activities by all levels of government.

In Huron County, the 100 kilometres of Lake Huron shoreline include:

- Dunes and beaches attracting recreation and tourism,
- Harbours requiring dredging and infrastructure maintenance capable of handling boating and commercial shipping at either extreme of lake level, and
- Majestic bluffs with sunset views that present challenges for emergency preparedness and public safety.

To date there appears to be no reliable way to identify a long-term trend in water levels, other than to predict there will continue to be both high and low extremes over time. What is perhaps more certain is the scientific opinion that global warming will bring an increase in extreme weather events, which tend to exacerbate the issues created by extremes of either high or low lake levels. This requires flexibility in consideration of practical policies, programs, and initiatives to address the full range of potential local issues and circumstances into the future.

This Integrated Assessment, funded by the Graham Sustainability Institute of the University of Michigan, and sponsored by the University of Toronto's Ecological Modelling Lab, brings together a multi-disciplinary research team, including local experts, with an advisory committee representing the wide range of Huron County community interests, to review the current status and trends, issues, and options for adaptation to on-going fluctuations in lake levels.

In Huron County, a number of initiatives are underway relating to extreme lake levels.

- Ausable Bayfield Conservation Authority (ABCA) is updating its Shoreline Management Plan, with public consultations underway and a final version expected in fall 2016. With the creation of a steering committee and consulting team, long-term erosion rates are being reviewed, shore processes assessed, shoreline protection evaluated, and policies reviewed.

- Maitland Valley Conservation Authority (MVCA), responsible for most of the county's bluffs, is developing a public education strategy. MVCA already has detailed hazard land mapping available to the public on its webpage and emergency preparedness information for homeowners. In 2014, the MVCA facilitated an erosion emergency exercise with the Township of Ashfield-Colborne-Wawanosh (ACW). There are plans to do a similar exercise with Central Huron in 2016.

- The Lake Huron Centre for Coastal Conservation (LHCCC) is planning to develop a Coastal Action Plan. The non-profit conservation organization works with the

conservation authorities and its shoreline municipalities providing shoreline management services and conservation programs.

- Huron County's Water Protection Steering Committee celebrated its 2000th funded project for conservation and stewardship on March 28th, 2016. The Committee is serving as the advisory committee for this Integrated Assessment study.

- The Town of Goderich is developing a Waterfront Master Plan for the area from the south side of the harbour (including the grain elevators) southward along the urban lakefront.

Integrated Assessment findings to date:

The Water Protection Steering Committee workshop, held on January 15, 2016, identified a need for improved public education about bluff erosion. In particular:

- How to ensure prospective buyers are aware of properties with hazard land designations, so they understand, and can be prepared for, potential risks.
- Ways to assist current owners to evaluate their individual property situations.
- Ways to engage property owners to take advantage of local resources. In addition to the on-line mapping and expertise of conservation authority staff, The LHCCC has bluff stewardship information for homeowners, together with a checklist.
- Information for property owners about what to do in the event of a slump.
- Information for property owners on "managed retreat" approaches.

There is a need to find new tools to help predict where bluff failures can be expected to impact existing buildings, in order to provide more certainty and timely warning to residents.

The Town of Goderich has the only deep-water port on the eastern shore of Lake Huron handling shipping for salt, grain, and calcium chloride. The port has been designated an official Seaway Port under the "Highway H_2O" program. This is a government and business initiative to market the Seaway and Great Lakes ports to international customers, which could result in new economic activity. A new plan for the harbour has been developed and approved by the Province of Ontario. The Approval Notice for the Environmental Assessment requires an Environmental Management Plan which takes into account high and low water levels and resilience to storm events as a result of climate change.

Tourism is also very important to the Town of Goderich, both as a destination and as a service center for neighbouring cottagers and beach/lakeshore visitors. The town is currently undertaking a public process to create a Waterfront Master Plan for the area from the south side of the harbour (including the grain elevators) southward along the urban lakefront. Workshops were held in January and April 2016. This project is taking ecology into consideration but it is not clear if high and low water level impacts or industrial development needs at the port have yet been discussed during the process.

The Village of Bayfield is anticipating both residential and tourism growth as a result of increased sewage treatment capacity. The Ontario Ministry of Tourism, Culture and Sport has

designated the Village of Bayfield as one of four towns in a large tourism region west of Toronto to receive assistance for marketing and other "destination development" initiatives.

Bayfield's connection to the lake and river mean the experience of low and high water levels can directly affect the village's economy. Low water is a particular concern as it limits the size and type of boats that can access the harbour and marinas. High water levels are good for the marinas but can generate more significant wave action on the piers at the river mouth.

Lake level extremes and climate change impacts will be key considerations in Village growth planning and management.

Once this year's studies and assessments are completed, and data is updated, Huron County and its local municipalities may want to review the status of infrastructure (such as roads, bridges, drinking water intakes, and sewage treatment plants) with a view to future adaptation to the impacts of extreme high and low lake levels. There may be financial assistance available through a new disaster readiness component of federal infrastructure funding targeted to "disaster resilient public works". (See January 14, 2016 Goodale announcement in Appendix 3.)

INTRODUCTION

In November 2015, the Graham Sustainability Institute of the University of Michigan approved funding for four integrated assessments of variable lake level impacts. The projects are:

1. Inclusion of Climate-Change Effects on Lake Levels in Management Plans of Tribal Fisheries
2. Integrated Assessment on Water Level Variability and Coastal Bluff Erosion in Northern Milwaukee County and Southern Ozaukee County, Wisconsin
3. Implementing Adaptation: Developing Land Use Regulations and Infrastructure Policies to Implement Great Lakes Shoreland Area Management Plans with two Michigan municipalities (the City of Grand Haven and Grand Haven Charter Township).
4. Extreme Lake Levels: Issues and Options for Huron County, Ontario

Integrated Assessment (IA)is an interdisciplinary and collaborative research methodology, which actively involves subject matter experts, decision-makers, and key stakeholders working to find sustainable solutions to address real-world sustainability problems.

The Water Protection Steering Committee (WPSC) is an interdisciplinary committee established by the County of Huron in 2004, with representatives from environmental, social, political, and economic interests. The current chair is Central Huron Mayor Jim Ginn.

The Project/Research team includes academics from the University of Toronto's Ecological Modelling Lab, an Environment Canada scientist, two former Ontario senior executives with expertise in legislation and policy development, a former municipal chief administrative officer, a Huron County farmer who is a professional writer and editor, and a student intern. Other contributors include the Lake Huron Centre for Coastal Conservation (LHCCC), the Maitland Valley Conservation Authority (MVCA), the Ausable Bayfield Conservation Authority (ABCA), and the county's Planning and Development Department. The Integrated Assessment project has the support of the County of Huron and its local municipalities.

The project began in late November 2015, with an overview presentation at the WPSC. A full-day workshop was held January 15, 2016 with the WPSC members and other invited participants (45 people). Committee members reviewed and discussed extreme lake level issues and the current status of regulatory and other tools and processes to address them. The WPSC established an Extreme Lake Levels subcommittee to continue more intensive work on the project with the research team.

The WPSC workshop identified two areas of extreme water level issues of most significance for Huron County communities:

1. Low water level impacts on economic development, tourism, shipping, ports, and harbours.
2. High water level impacts on bluff and gully erosion.

Issues relating to environment, habitat, invasive species, and coastal resiliency were also discussed, particularly in relation to potential climate change impacts, and may lead to additional research and more elaboration as a result of consultations. There was a concern, as well, about

the potentially negative impacts of diverting Great Lakes water, as requested recently by a Wisconsin city (details in Appendix 3).

This report completes Phase I of the Integrated Assessment process for the Huron County project. Sections below summarize research undertaken by team members, discussions and input from the WPSC at the January 15 workshop, and suggestions from a dedicated subcommittee of the WPSC at an April 1 meeting.

Next Steps:

Phase II is the consultation phase, ongoing through spring and summer 2016, to confirm issues and develop options. Some research will continue at the subcommittee's direction. Following the April 1 meeting, a presentation will be developed for use at summer events, including:

- May 14 Ashfield-Colborne Lakefront Association annual meeting
- May 27 "Is the Coast Clear" conference
- June 4 Bluewater Shoreline Residents Association annual meeting
- ABCA Shoreline Management Plan public meetings (schedule tbd)
- Other events on request

For the WPSC September 23 meeting, a draft final report will reflect the summer input on potential options to address the IA Question:

What environmentally, socially, politically, and economically feasible policy options and management actions can people, businesses, and governments implement in order to adapt to current and future variability in Great Lakes water levels?

STATUS AND TRENDS
Current Conditions and Historical Trends

Huron County: where farm meets lake

The focus area for this Extreme Lake Levels Integrated Assessment is the Huron County, Ontario, Canada, shoreline of Lake Huron. Huron County, population 60,000, is a rich agricultural region with tourism and manufacturing contributing to the local economy. The 100 kilometres (62 miles) of Lake Huron shoreline is a prime attractor for tourism and recreation activities. Summer theatre, farm-based promotions, and local festivals complete the attractions. The Town of Goderich is the county seat and a center of marine activity, both industrial and recreational. It has the only seaway depth port on the east side of Lake Huron. A second significant harbour is located at Bayfield, Ontario, with commercial, fishing, and recreational boating activities. The Huron County shoreline contains the only bluffs on the east side of Lake Huron; the bluffs are subject to erosion. The county also has more than 130 streams flowing into Lake Huron, which are also subject to erosion, exacerbating coastal erosion as they carry storm water and agricultural runoff to the lake. To the south along the lake are major tourist and recreational attractions including the Pinery Provincial Park, dunes, beaches, and resorts.

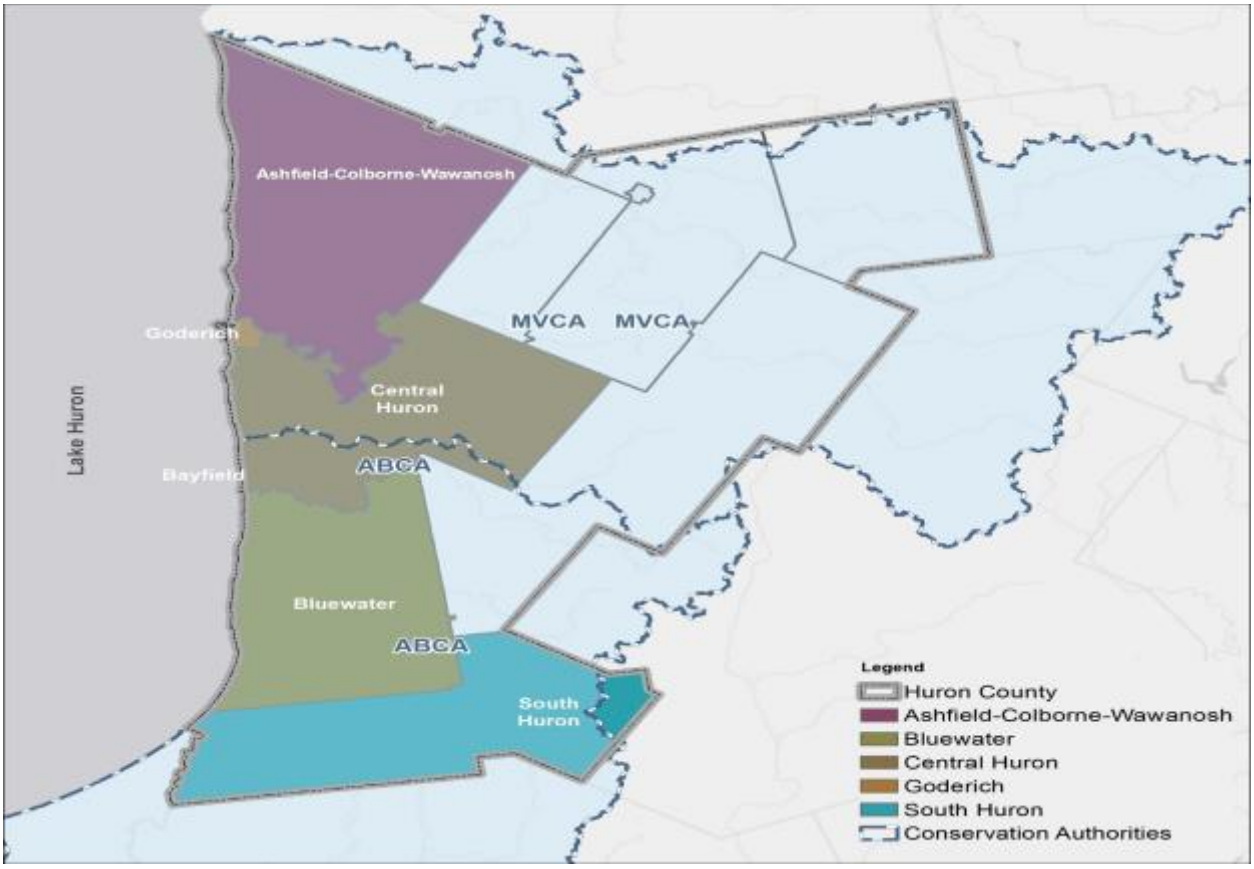


Figure 1: Huron County, with municipalities and conservation authority jurisdictions.

Changing lake levels: uncertain science

Lake Huron water levels fluctuate in response to three main hydrologic variables: overlake precipitation, lake evaporation, and drainage basin runoff (Notaro, Bennington, and Lofgren, 2015). Seasonal patterns in these variables produce short-term water level fluctuations of about 0.4 m amplitude (Lofgren et al. 2002), while long-term changes result in larger fluctuations. Canadian Hydrographic Service (CHS) hourly water level data for Lake Huron, recorded at Goderich, shows that the lake level has fluctuated within a range of about two metres (m) over the past century.

It is uncertain how much long-term changes in regional climate will affect future water levels in the Great Lakes. For example, MacKay and Seglenieks (2013) reviewed lake level projections for Lake Michigan – Huron illustrating a wide range of possibilities with levels increasing by up to 1 m and decreasing by 2m. Their projections also showed that the fluctuations in lake levels will increase on a seasonal basis (see Appendix 1-3 for further details). A new report released April 7, 2016 (see press release in Appendix 6) by the Council of Great Lakes Region (CGLR) and the Mowat Centre also concludes that uncertainty about future water levels and gaps in data affect climate adaptation decisions.

Climate models for the Great Lakes region project increases in air and lake surface temperatures and lake evaporation, which would reduce the net supply of water to the lakes (Millerd 2011; Lofgren et al. 2002). However, precipitation is also expected to increase (Notaro et al. 2015), having the opposite effect. Projections of drainage basin runoff have been inconsistent (Notaro et al. 2015; Millerd 2011; Lofgren et al. 2002). How these different factors play out will determine water levels in the future.

According to the National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA), world temperatures are increasing. 2015 marks the fourth time in the 21st century a new record high annual temperature has been set (along with 2005, 2010, and 2014) and also marks the 39th consecutive year (since 1977) that the annual temperature has been above the 20th century average. To date, including 2015, 15 of the 16 warmest years on record have occurred during the 21st century. 1998 is currently tied with 2009 as the sixth warmest year on record. Overall, the global annual temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880 and at an average rate of 0.17°C (0.31°F) per decade since 1970.

Climate experts have noted that the frequency and intensity of severe storms has increased (Synthesis of the Third National Climate Assessment for the Great Lakes Region, 2014, GLISA). Potential impacts from severe storms include the disruption of business and transportation, and poor water quality. Climate modelers are improving their knowledge about the interaction between regional climate and water levels. However, accurate multiple year forecasts are more difficult to achieve than seasonal forecasts. The United States Army Core of Engineers (USACE) and Environment Canada produce seasonal Great Lakes water level forecasts monthly. NOAA is working alongside the USACE and Environment Canada to improve the accuracy of weather prediction models for the Great Lakes region. A significant challenge remains in monitoring and predicting Great Lakes evaporation, primarily driven by a large temperature difference between

warm water and cold air, low specific humidity, and high wind speeds.

Canada's Regional Adaptation Collaborative (RAC) Climate Change Program was created to coordinate research, planning, and action related to climate change adaptation. Two RACs were located in the Great Lakes region – Quebec and Ontario. The Quebec RAC focused its climate change adaptation efforts on three themes: built environment, water management, and socioeconomic activities, such as forestry, agriculture, tourism, and recreation. The effort was led by the Ouranos organization, a climate change consortium with over 20 partners in the federal, private, and non-governmental worlds.

The Ontario RAC focused its efforts on three themes: extreme weather risk management, water management, and community development planning. The effort has been led by the Ontario Ministry of the Environment with partners in the Ontario Ministry of Natural Resources, Ontario Ministry of Municipal Affairs and Housing, Clean Air Partnership, Ontario Centre for Climate Impacts and Adaptation Resources, Toronto and Region Conservation Authority, Association of Canadian Educational Resources, Institute for Catastrophic Loss Reduction, York University, and Toronto Public Health. The entire RAC Program ended in December 2012. Natural Resources Canada planned to build on the efforts of the RACs through a new initiative called the Adaptation Platform (2011-16).

While they may be difficult to predict, extreme lake levels are not an unusual phenomenon. In the last 50 years, Lake Huron has registered three extreme levels scenarios where records have been set. Record lows for Lake Huron were experienced in 1964 and January 2013. Record highs were experienced in 1985-86. Figure 2 shows the periods of high and low water levels over the last century. Preliminary retrospective (1995 to 2014) analysis using hourly data from the CHS for the Goderich station in Lake Huron shows that lake levels fluctuate hourly, daily, weekly, and monthly basis and that these fluctuations change from year to year (see Appendix 2).

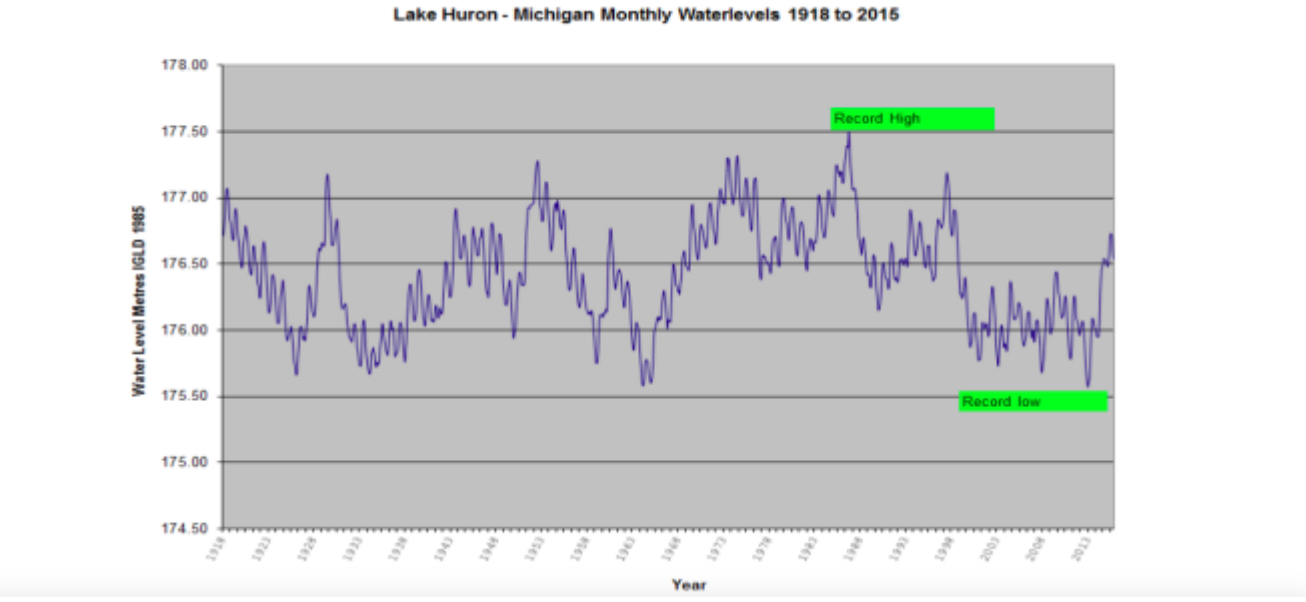


Figure 2: A century of lake level variations. Source - Ausable Bayfield Conservation Authority

In addition to rising temperatures, precipitation also has been increasing over the past century. Figure 3, below, shows how the precipitation in the Great Lakes Basin has changed during the period from 1900 to 2000. The Great Lakes Drainage Basin includes the Great Lakes themselves, plus all the surrounding land that drains into them, in both Canada and the U.S.

Looking at the decades from 1900 to 1940, it was not that common to have annual rainfall amounts of 800 mm, and never did the annual rainfall exceed 900 mm. Between 1940 and the mid 1960's, more years had annual rainfall amounts of 800 mm than did not, and several years saw rainfall amounts over 900 mm. After 1964, there are very few years that have less than 800 mm of annual rainfall, and many years exceeded 900 mm. It is also interesting to note that during the first 40 years of the 20th century, the record annual rainfall amount was just slightly less than 900 mm. During the last 40 years, the record annual rainfall amount was 1020 mm.

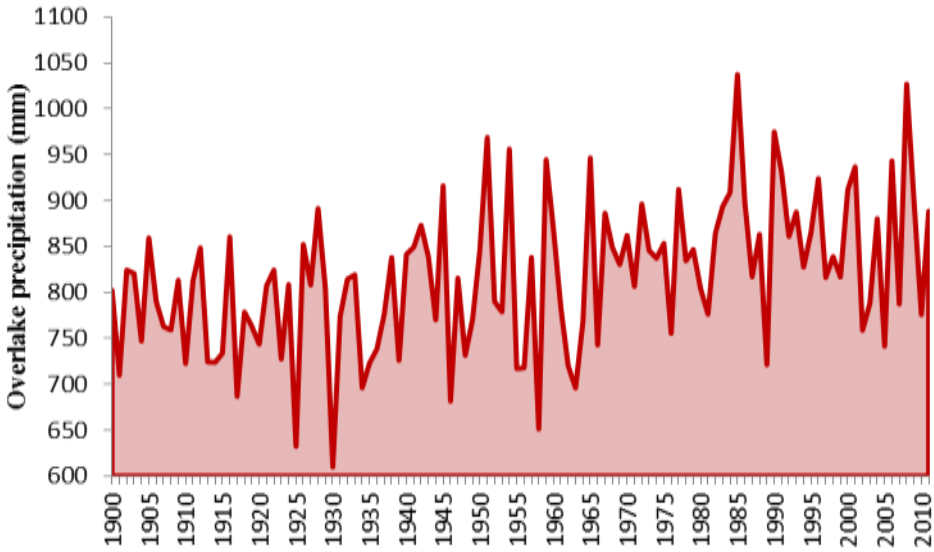


Figure 3. Overlake precipitation for Lake Michigan-Huron using data downloaded from the Great Lakes Environmental Research Laboratory (GLERL) dashboard.

While much is uncertain, science indicates that we can most likely expect continuing extremes of both high and low lake levels over time, increased frequency of extreme storms, increased annual precipitation, and increasing global and lake temperatures. Changes in runoff and lake levels are presented in Appendix C.

Low water levels status and trends

The economic engine of Huron County is agriculture, accounting for approximately 85% of business activity. Other important sources, more closely related to the lake and shoreline, are tourism and shipping. There are two harbours on the county's Lake Huron shoreline: The Village of Bayfield and the Port of Goderich. Most of the last decade has been a "master class in low water levels", according to local officials. Low lake levels meant wide, sandy beaches attractive to tourists, but lower lake levels meant difficulty for commercial Great Lakes shipping, fishing, and recreational boating. Shoreline docks were often entirely out of water as the lake edge receded, and marinas experienced reductions in the size of boats which could be accommodated. Dredging and adjustments to harbour infrastructure was required. Municipal water intakes had to be carefully monitored.

Great Lakes Shipping

The Great Lakes commercial shipping industry is a vital part of the region's economy, providing an efficient and low-cost means of transporting bulk commodities such as grain, iron ore, coal, salt, petroleum products, limestone, and pulpwood (De Loe, Kreutzwiser, and Moraru, 2001; Millerd, 1996). Each year, approximately 250 million tonnes (176 million U.S. tons) of cargo are shipped through the Great Lakes-St. Lawrence system (De Loe et al., 2001), supporting over 30,000 jobs and contributing $7 billion to Ontario's economy (Expert Panel on Climate Change Adaptation 2009; Lindeberg and Albercook 2000).

A decline in average water levels and increase in the frequency of extreme low water events increases costs to shipping in the Great Lakes. During times of low water, shiploads must be reduced in order to maintain the same clearance in shallower channels and harbors (Kling et al., 2003). It is estimated that every 2.5 cm (1 inch) of lake level decline results in 245 tonnes (270 U.S. tons) of lost cargo capacity per ship for 305 m (1,000-foot) vessels, and 90.72 tonnes (100 U.S. tons) of lost cargo capacity (U.S.$11,000–$22,000 lost daily profits) per ship for oceangoing vessels (Lindeberg and Albercook, 2000; Wang et al., 2012). Reduced loads also will mean that more trips are required to transport cargo, leading to increased traffic and potential backups at bottlenecks such as the Welland Canal and Sault Ste. Marie locks (Hartmann, 1990).

Millerd (2011) estimated the impact of lower lake levels on vessel operating costs due to reductions in cargos and increased number of trips. Average annual vessel operating costs were calculated using the 2001 volume of international cargo shipments applied to three different scenarios of average water level decline for Lake Huron: -0.72 m, -1.01 m, and -1.62 m. Results indicate that average annual vessel operating costs for all imports and exports could increase by 4.8% to 22% compared to the 1900-1989 period, depending on the water level scenario (Millerd, 2011). These added costs could be quite detrimental to the Great Lakes shipping industry, and also would have direct effects on other industries that rely on shipping for transport of materials (Hartmann, 1990).

Additional costs of low lake levels for the shipping industry include those associated with adjusting shoreline infrastructure, such as docks and loading/unloading facilities, and dredging

channels and harbors to improve ship clearance (Kling et al., 2003). More frequent dredging of channels and harbors is of particular concern since the costs of dredging are both economic and environmental (Kling et al., 2003). The direct costs of dredging and disposal of the contaminated material can be significant. Magnuson et al. (1997) estimated dredging costs of up to U.S. $31 million per harbour for scenarios of 0.5–1.5 m decline of water levels on the Great Lakes. Furthermore, in many locations, lake sediments are contaminated with toxins from industrial waste and spills (Hartmann, 1990). Dredging activities can have environmental costs through the release of these toxins into the water, and also through the destruction of lakebed habitats (Lindeberg and Albercook, 2000; Magnuson et al., 1997).

High water levels status and trends

Water levels have rebounded since 2014, improving conditions for commercial shipping and recreational boating. Marina owners are pleased, but beachgoers have noticed the smaller span of beach compared to other years. Lake Huron experienced record highs in 1985/86 and another spike in lake levels in the early 90s.

Combined with precipitation, high lake levels are now affecting erosion rates as wave action eats away at the toes of bluffs, and porous bluff soils absorb large amounts of rain and storm runoff. More than 130 streams flow into Lake Huron along the Huron County coast. The erosion of these waterways from high flows has created ravines and gullies. Houses and other structures along the gullies are also threatened by erosion.

Erosion is a natural, cyclic process of dynamic coasts and has beneficial impacts to downshore areas, renewing dunes and beaches in Huron County's southern shoreline and beyond to important tourism centres such as Grand Bend and its beaches. However, it can also result in damage to shoreline residences and potential hazards to human life. In the 1960s, when the majority of cottages were built along the 50 km of Huron bluff, they were set well back from the bluff edge, but erosion over the ensuing years has caught up with them. To date, Huron County has been "lucky to not have had any loss of life or serious injury," according to local authorities, who are now back on alert as the high water levels and precipitation have increased erosion potential (see MVCA webpage alert in Appendix 6).

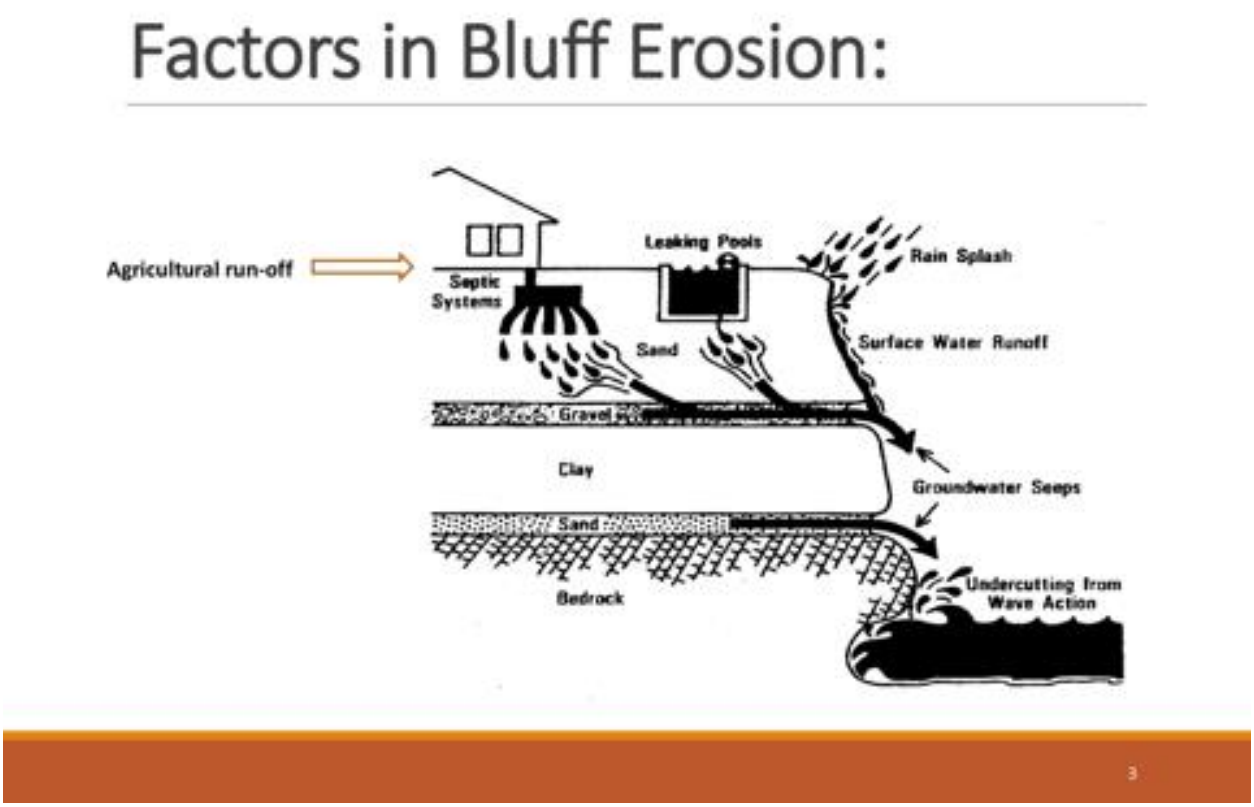


Figure 4: Commonwealth of Pennsylvania, Department of Environmental Protection, Fact Sheet: Bluff Recession: A Lake Erie Coastal Hazard, 2008, pg. 3

Ontario's regulatory environment for shoreline development

For land use planning and development, the province of Ontario provides policy direction through the Provincial Policy Statement (PPS). Sections 3.0, 3.1.1, and 3.1.2 direct development away from areas of natural hazards with an estimated planning horizon of 100 years. Development includes new lot creation, any change in land use, and construction of buildings and structures that require *Planning Act* approval.

In 2014, the PPS was amended to include the requirement that climate change mitigation and adaptation be considered as follows:

- Land use patterns and densities in settlement areas to minimize negative impacts to air quality and climate change, and promote energy efficiency,
- Promote compact built form, intensification, efficient transportation (1.6.7.5) and active transportation (1.6.7.4), energy efficient design, and alternative energy systems (1.1.3,1.7,1.8),

- Planning authorities to consider and minimize the impacts of climate change that may increase the risk associated with natural hazards (3.1.3),
- Development shall generally be directed to areas outside of hazardous lands adjacent to the shorelines of the Great Lakes (3.1.1),
- Development and site alteration shall not be permitted within areas that would be rendered inaccessible during times of flooding hazards, erosion hazards and/or dynamic beach hazards (3.1.2),
- Encourage green infrastructure (e.g., permeable surfaces) and promote storm water management best practices (1.6.2, 1.6.6.7).

Ontario has a "policy-led" land-use planning framework as illustrated in the graphic below, with the province setting the policy regime through the *Planning Act* and PPS and municipalities implementing those policies through development of their Official Plans and zoning by-laws. Designated agencies such as conservation authorities play a key role in regulating and permitting processes for development in areas that may subject to flooding, erosion or dynamic beach hazards.

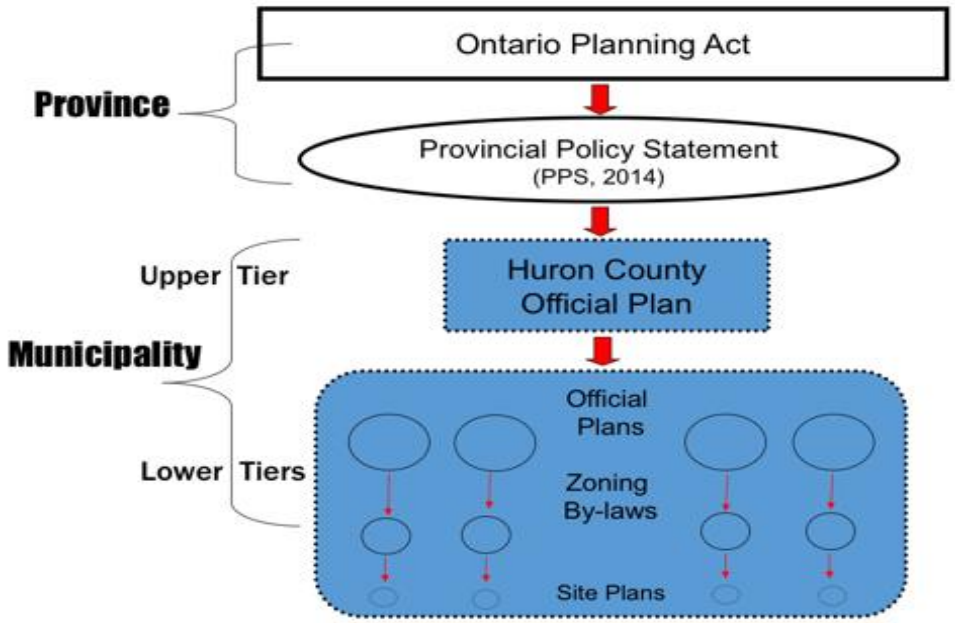


Figure 5: Ontario's planning system illustrations prepared by Susanna Reid, Huron County Planning and Development 2016.

Conservation Authorities' role

Within Huron County there are two conservation authorities, the Maitland Valley Conservation Authority (MVCA) and the Ausable Bayfield Conservation Authority (ABCA).

Ontario's conservation authorities (CA) are organized on a watershed basis. They have the responsibility to implement Provincial regulations for natural and hazardous areas in order to:
- prevent the loss of life and property due to flooding and erosion, and

▪ conserve and enhance natural resources.

This is done through implementation of provincial regulations affecting areas in and near rivers, streams, floodplains, wetlands, slopes, and the Lake Huron shoreline. They work with municipalities to review development applications to ensure they meet local and provincial environmental standards. In Huron County, projects may need an MVCA or ABCA permit, approval under The Planning Act, or both.

The conservation authorities have geographic information systems (GIS) and satellite mapping, water level data analysis, and erosion mapping with land-use policies. They work with municipalities and local stakeholders on shoreline management plans. For example, the ABCA's first Shoreline Management Plan was completed in 1994, with an update in 2000 and a new review underway in 2016.

CAs represent the province with regard to natural hazards. CAs are the delegated lead commenting agencies with respect to Section 3.1 of the PPS. They are the permitting agency in natural hazard areas – Section 28 of the *Conservation Authorities Act* for:

- control of flooding and erosion,
- protection of life,
- prevention and reduction of damages and social disruption arising from naturally hazardous lands, and
- conservation of ecosystems.

CAs were delegated the responsibility for Great Lakes shorelines and connecting channels in 1988.

Before any development within a natural hazard area can begin, a permit is required under Section 28 of the *Conservation Authorities Act*. From this, Ontario Regulation I47/06- ABCA Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses and Ontario Regulation 164/06 for MVCA were created. This includes any development in areas defined as floodplains, river and stream valleys, wetlands, and shorelines.

The *Conservation Authorities Act* defines development as any of the following:

- the construction, reconstruction, erection or placing of building or structure,
- any change to a building or structure that would have the effect of altering the use, increasing the size or number of dwelling units, and
- site grading or temporary placing, dumping, or removal of any material, originating elsewhere or on the site.

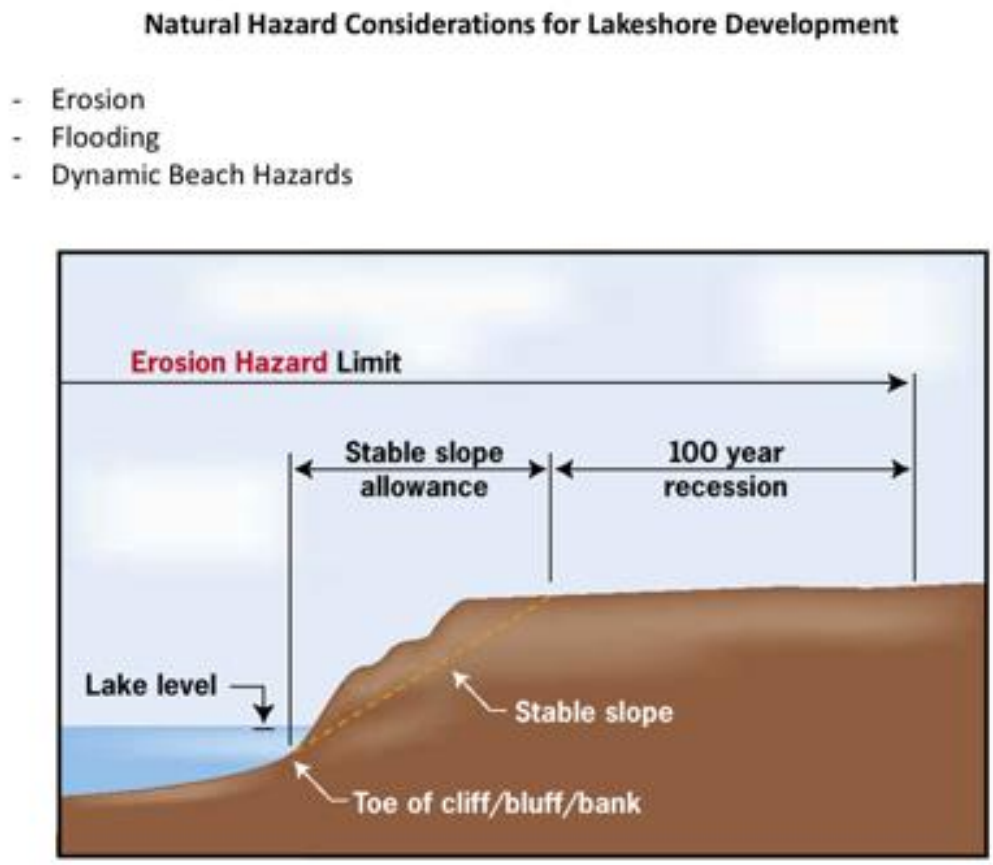


Figure 6: Illustration from S. Reid's January 15, 2016 presentation on the Ontario land-use planning system. Source: Ausable Bayfield Conservation Authority.

CAUSES AND CONSEQUENCES

Each time lake levels have spiked, there has been public concern and call for action. At the request of the Canadian and United States governments, the International Joint Commission (IJC) undertook a series of bi-national studies on lake level issues, starting with the *Interim Report on 1985-86 High Water Levels in the Great Lakes-St. Lawrence River Basin,* of October 1988. The 1992/93 IJC Lake Levels Reference Study considered actions to address extreme high levels. It concluded with a December 1993 Report to the Governments of Canada and the United States on *Methods of Alleviating the Adverse Consequences of Fluctuating Water Levels in the Great Lakes-St. Lawrence Basin* with 43 recommendations.

In this report, the study board recommended against the installation of new structures to further regulate the levels of flows of the Great Lakes and St. Lawrence River because its investigations demonstrated that the costs of such measures would outweigh their economic benefits and produce negative environmental effects. In particular, the effect on wetlands was evaluated as a primary indicator for impacts on fish, wildlife, and other environmental aspects. The study board concluded that the reduction in the range of water level fluctuations resulting from water level regulation has adversely affected the extent and diversity of Lake Ontario's wetlands. In addition, the study board concluded that regulation of Lake Ontario has caused losses of floodplain forests along the St Lawrence River through flooding and erosion.

A 2013 IJC report, following a five-year study by the International Upper Great Lakes Study (IUGLS) team of low lake level issues, confirmed that further exploration of multi-lake regulation that includes new large-scale dams and channel enlargements is not warranted. It recommended implementation of an adaptive management approach to the Great Lakes, supported by science and monitoring.

The recent decade of low water levels also prompted substantial regional public pressure, particularly from Georgian Bay, for construction of engineered structures in the St. Clair River aimed at holding back water in the Lake Huron/ Lake Michigan system. The structures discussed would be aimed at raising the levels by about 20 cm. A similar proposal was made in the 1960s during the last extreme low level, but was not implemented (History of Dredging and Compensation in the St. Clair River, 2009). As the LCCC Position Statement on Lake Huron Extreme Lake Levels comments, "What followed was three consecutive decades of high lake levels, including the record highs in the mid-1980's. Had the structures been in place during that time, greater flooding and erosion damages would likely have been experienced." (pg. 6)

There are competing interests involved in extreme lake levels. High lake levels favour shipping and recreational boating, but can accelerate bluff erosion, which affects public safety and property values. Low water levels favour tourism with broad, sandy beaches, but can make marina operation unprofitable and require expensive dredging and other harbour infrastructure maintenance to ensure continued harbour functions. Both extremes have impacts on coastal wetlands, habitat and biodiversity.

Most recently, an April 7, 2016 press release (see Appendix 6) announced a new report from CGLR and the Mowat Centre which concludes that uncertainty about future water levels and

gaps in data affect climate adaptaion decisions. The report set out to assess the costs and benefits of the three commonly proposed responses to fluctuations in Great Lakes water levels:

- building dams or water-controlling structures to restore historic water levels in Lake Michigan-Huron and especially Georgian Bay;
- creating a system of water-controlling structures to manage water levels throughout the Great Lakes system; and
- adaptive management, which entails finding new and better ways of adapting to changes in water levels informed by bi-national monitoring, modelling and assessment of hydrological trends and impacts.

Researchers found that available data did not allow for a credible quantitative analysis of all three approaches and their economic impact across the region.

Lake levels – impact on tourism and industry

Village of Bayfield and Harbour

Founded in 1832 at the mouth of the Bayfield River, the village of Bayfield in its earlier years served as a stop for vessels travelling between Detroit and Goderich. In 2001 it was amalgamated with surrounding areas into the Municipality of Bluewater. The Bayfield River serves as the boundary between Bluewater and the municipality of Central Huron to the north.

Bayfield is now predominantly a tourist destination. Most activity occurs from spring through fall. Permanent population in 2011 was 883. In summer this number swells to around 3,000, weekend visitors push this to 4,500. Cottagers and boaters from the cities of London and Kitchener-Waterloo are the largest group of seasonal visitors although more are now being attracted from the Greater Toronto Area (GTA) to the east. American visitors arriving by boat declined after 9/11 and again after the 2008 financial crisis. It is possible that the presently lower value of the Canadian dollar against the American dollar may reverse this trend.

The main tourist activities include boating, sport fishing, cycling, hiking, and beach-going. Related services such as restaurants, B&Bs, marinas, and shops provide the bulk of economic activity. Four marinas provide 430 slips in season, which are well used since the adjacent shoreline is not suitable for building docks out into Lake Huron.

There is also a small fishing fleet operating on Lake Huron from Bayfield, which increases the need for maintenance of the harbour entry into the lake.

The municipality, the federal government, and the marina owners and operators have all recognized the importance of the river and lake and the impact of low water levels. Each year the marinas identify a need for dredging to maintain a minimum depth of 2.74 m (9 feet) at the river mouth and 1.83 m (6 feet) upstream. The municipality submits a request to the Federal Department of Fisheries and Oceans to start the approval process. All three parties (municipality, federal government and marine owners/operators) contribute to the cost of the required work. Repairs have been made to piers on the north and south side of the harbour; these reduce the effect of waves and siltation on the harbour mouth. They also provide access to the lake for sports fishers.

Figure 7: Bayfield River and Harbour photograph. Source: Healthy Lake Huron

More economic activity is on the way for Bayfield: a sewage treatment plant expansion or replacement is upcoming, which will support more housing, either seasonal or permanent. The Ontario Ministry of Tourism, Culture and Sport has designated Bayfield as one of four towns in a large tourism region west of Toronto to receive assistance for marketing and other "destination development" initiatives.

Bayfield's connection to the lake and river mean the experience of low and high water levels can directly affect the village's economy. Low water is a particular concern as it limits the size and type of boats that can access the harbour and marinas. High water levels are good for the marinas but can generate more significant wave action on the piers at the river mouth.

Summer consultation sessions will ask what adaptive management actions and options might be useful for Bayfield to consider as it grows.

Port of Goderich

The Town of Goderich, at the entrance of the Maitland River into Lake Huron, is the county seat with a 2011 population of 7,521. It has a significant asset: a deep water port, the only one on the eastern shore of Lake Huron. The depth of the harbour is 7.9 m (26 feet), which allows Saint Lawrence Seaway ships to access the port. 250 to 280 ships dock there each year and the season runs for about nine months a year.

Harbour development began in the 1820s. Port ownership has varied throughout the years. In 1872 the river was shifted north to allow the port to be expanded to its present size. Grain elevators built in the 1920s are still in use. Three major users are: Compass Minerals (salt mine), Dar-Leigh (calcium chloride) and Goderich Elevators (grain). The Sifto Salt Mine was developed in the 1950s and the first seaway ships began to serve it in 1959. Today the mining operation owned by Compass Minerals has approximately 500 employees and generates 90% of the annual use of the port.

After the federal government in 1995 began divesting its ownership of ports, Compass Minerals expressed an interest in buying the Goderich port. The town did not agree and a compromise was reached: a public-private partnership was formed and the town purchased the port in 1999. The non-profit Goderich Port Management Corporation (GPMC) was established to manage the port. The users pay fees (currently $1.5 million per year), which fund operating and capital improvement costs. The GPMC developed a 15-year plan to remediate the river wall, piers, and breakwalls. Town council approves projects and construction timing. Almost all user fees go towards the operation and upgrades; the town receives $175,000 per year from the fees to use for waterfront improvement.

The 15-year plan is now complete and a new plan proposes to landfill next to the existing wharf to permit additional storage and docking space. An Environmental Assessment Approval has been issued by the Ontario Ministry of Environment and Climate Change, although not all funding is in place to do the work.

The Approval Notice requires an Environmental Management Plan that takes into account high and low water levels and resilience to storm events as a result of climate change. The new plan does so by expanding the wharf to provide additional docking spaces, material storage space and wave protection features on the outer harbour.

Low water levels in the harbour force lake freighters to carry lighter loads, increasing the cost per ton of cargo. High water levels are less of an issue since adjustable cranes permit cargo to be loaded with relative ease. Improvements to breakwaters and piers have calmed harbour waters and reduced the impact of siltation from the lake.

The expansion of the port would provide existing users the means to expand their operations (especially the salt mine) but its real value is in attracting new users of the port. More users would equal a wider sharing of risk and costs. Diversification could add more local jobs. Topography and existing shoreline development prevent expansion inland so the landfilling program is an important project for future economic development of the port. It also enhances the reputation of the port, which has been designated an official Seaway Port under the "Highway H_2O" program, a government and business initiative to market the Saint Lawrence Seaway and Great Lakes ports to international customers.

Tourism is also very important to Goderich, both as a destination and as a service center for neighbouring cottagers and beach/lakeshore visitors. The town is currently undertaking a public process to create a Waterfront Master Plan for the area from the south side of the harbour (including the grain elevators) southward along the urban lakefront. Workshops were held in

January and April 2016. *This project is taking ecology into consideration, but it is not clear if high and low water level impacts or industrial development needs at the port have yet been discussed during the process.*

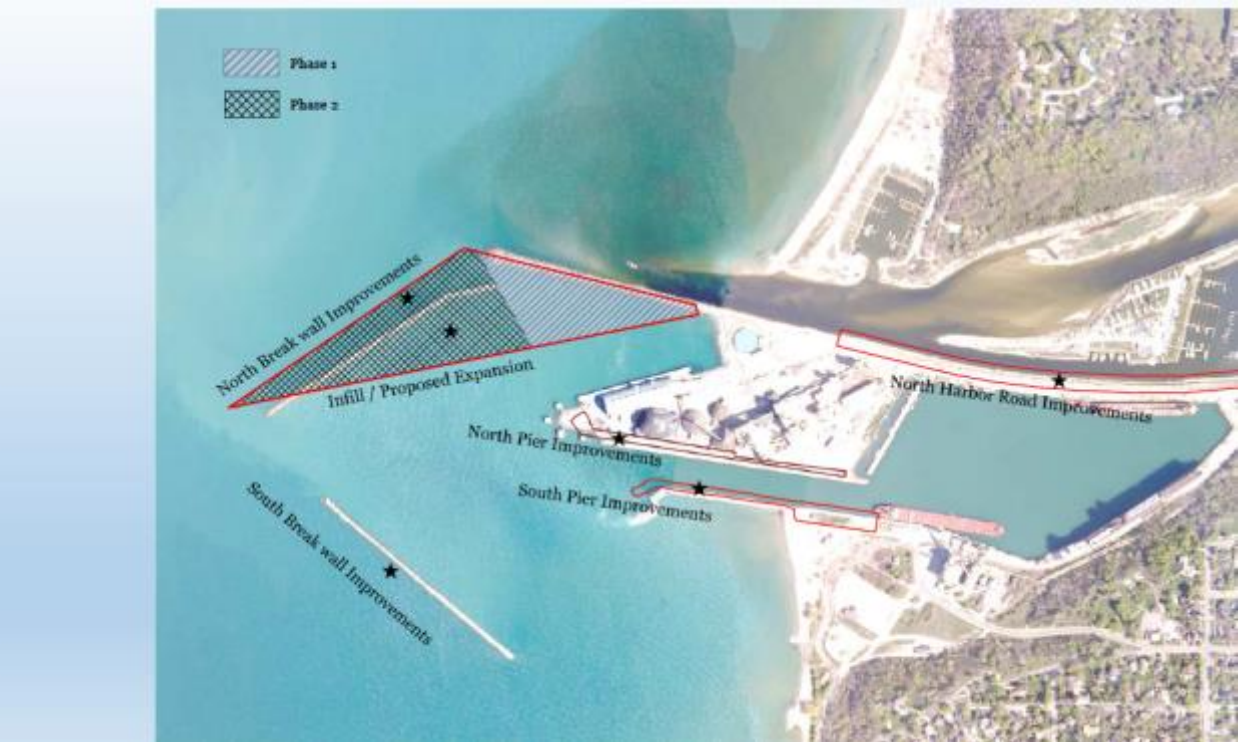


Figure 8: Goderich Harbour Improvements. Source: Goderich Port Management Corporation

Great Lakes Shipping

The Great Lakes shipping industry may face significant added costs due to low water levels at various times in the future, or could benefit from high lake levels and a longer shipping season. Global economics will also affect the industry. With the only certainly likely to be a continuing cycle of water level extremes, both high and low scenarios have to be considered in future planning.

As a major Great Lakes shipping port in Huron County, the Port of Goderich will be affected by lake-wide impacts to the industry. Current traffic - about 250 ships docking per year according to the Port Management Corporation - might be expected to increase, and higher vessel operating costs would directly affect the salt mining industry at Goderich, which relies on shipping of its product.

However, many adaptation options exist that, if implemented, could lessen the impact of extreme low water levels. De Loe et al. (2001) divided these adaptation options into three main categories: accepting losses, preventing effects, and changing uses or locations. For example, "accepting losses" could include developing contingency plans for shipping delays, "preventing effects" might mean adjusting vessel loading facilities, and "changing uses or locations" could

involve rescheduling shipments based on seasonal water level fluctuations (De Loe et al. 2001). While not all of the measures outlined by De Loe et al. (2001) are applicable to Huron County, the identification of these options is a starting point in the process of adaptation.

A potentially positive effect of climate change was discussed during the January 15 workshop – longer shipping seasons resulting from higher temperatures. "From the 1950s to 1995, ice made the waters of the Great Lakes non-navigable for 11-16 weeks each winter by blocking navigation lanes, ports, and locks in the system. Warmer water and air temperatures will likely reduce the ice cover somewhat, extending the shipping season," (Gregg, Feifel, Kershner, and Hitt, 2012). Global economic shifts, however, may have a bigger determining impact.

A March 26, 2016 two-page feature in the Globe and Mail titled "Fleeting Prospects", describes the Great Lakes shipping industry as going through one of the worst times in its history, with no change likely for some time. Originally fueled by Chinese demand, shipping rates for coal, iron ore and grain, measured by the Baltic Dry Index, have plunged to record lows this year. As steel and its related commodities have plunged in demand, grain has emerged as the Seaway's top commodity, and growing. The port of Thunder Bay, and increasingly Hamilton, are major links between farmers and grain traders and buyers in Europe, Africa, the Middle East, and Latin America. Good news for Goderich is that demand for road salt, the staple of the Goderich harbour industry, continues to be steady.

An October 22, 2015 Toronto Star article, however, described a "Dawn of a 'new era' for Great Lakes shipping" with $4.1B being invested in a fleet of "brand new ships that are the sleekest, the greenest, the most technologically advanced commercial vessels on the water today". The new ships will replace existing freighters more than 35 years old. According to Stephen Brooks, president of the Chamber of Marine Commerce - a binational organization that represents shipping companies, ports and the industries that rely on them – the industry creates $35 billion in business revenues and sustains nearly 227,000 jobs. Smith would like to see more cargo containers ferried across the Great Lakes to ease road congestion, and more diverse loads. "The system is fundamentally underutilized, and could handle twice the activity that it does now" he says of the Great Lakes waterways.

Bluff Erosion - public safety, emergency planning, public education, managed retreat.

Historically, human beings have been drawn to the water banks, and today, waterfront property commands premium prices. Potential property owners appreciate the spectacular views, natural beauty, serenity, and recreational potential of a waterfront home. However, in the rush to buy their "waterfront retreat" they may underestimate the potential erosion of their land and consequently of their investment.

This situation can place governments, particularly municipalities, in a quandary, as they must balance the public benefit against the private good. On the one hand municipalities derive property tax dollars from waterfront properties with high market values, while on the other hand, they are faced with the questions of whether and to what extent, they are responsible for buyers' personal purchasing decisions, as well as their safety where real property is subject to erosion.

Various factors affect how local authorities and individual property owners deal with bluff erosion. Matters such as aesthetics, historic or ecological preservation, and finances influence their decisions.

Overall there are four ways that have been used to deal with bluff erosion:

- By constructing hard structures such as rip-rap, break walls, sea walls, or revetments,
- Through bioengineering or soft stabilization with vegetation and plant materials,
- Using biotechnical stabilization, by combining hard structures and vegetation, and
- Implementing clear policies and regulatory means to control human impact.

Sometimes, a combination of these approaches has been used.

Where the bluffs or shoreline are undeveloped and have a high ecological value, a government might institute a policy of "do nothing" to maintain the public interest. However, where there is existing private development or a public facility, it may require some compromise between the public and private interest.

Higher order governments and local municipalities institute legislation and municipal codes/bylaws to regulate land uses on bluffs and shorelines. Even where the governments have a policy of non-interference and adaptation to the natural processes they depend upon land use controls. Such regulations are designed to limit human impact of unsustainable development on or near a bluff top, slowing down erosion and extending the life of the development.

In Ontario, conservation authorities represent the Province with respect to natural hazards. In Huron County, the ABCA jurisdiction stretches 57 kilometres along Lake Huron from the north end at Lot 30, Concession 1, Goderich Ward of Central Huron, to the south end at the community of Port Franks, in the Municipality of Lambton Shores. This diverse shoreline can be divided into three areas; the bluffs north of Grand Bend, The dune region south of Grand Bend, and three river mouths at the communities of Bayfield, Grand Bend, and Port Franks. The ABCA website has indicators for low water and flooding status. An update to the Shoreline Management Plan is underway in 2016.

The MVCA covers the watershed, or drainage area, of the Maitland, Nine Mile, and Eighteen Mile Rivers, along with smaller watersheds along Lake Huron. It includes 50 km of bluff, the only bluffs on the eastern shore of Lake Huron. Hazard mapping has been done for the entire coastline and is available online. The MVCA has historical erosion rate information, and mapping that helps identify high risk areas.

On April 23, 2016, the MVCA posted a notice on its website advising shoreline municipalities and residents of a heightened risk for bluff collapse and gully erosion along the Lake Huron shoreline, as follows:

"There are several factors contributing to this risk. Although temperatures have been fairly mild, it has been quite a wet winter. Maitland Conservation staff report that the 30-year average for January to February rainfall is 30 mm and the average snowfall is 100 cm. In 2016 the watershed received an average of 63 mm of rain and 120 cm of snow. Mild winter temperatures

have resulted in several freeze-thaw cycles over recent weeks so rain has been falling on unfrozen ground.
These two factors have saturated the land and softened the clay till bluffs making them more unstable. This can lead to slope failures along the shoreline and increased gully erosion.
In addition, lake levels are forecast to be higher this year as compared to 2015. High wind and wave action could erode the base of the bluffs in some areas.
"Bluff failures are very unpredictable in terms of when they will happen, or how extensive they will be," reports Stephen Jackson, Flood and Erosion Safety Services Coordinator with Maitland Conservation. "It's important that landowners be aware of the risk and have a plan in place in case of a significant failure."
Maitland Conservation would like to remind shoreline residents that there are inherent risks associated with development along Lake Huron. Bluff erosion is a natural process along the lake that needs to be recognized and respected. Conservation authorities provide information on bluff and gully erosion, and shoreline regulations, to landowners and municipalities. Landowners are encouraged to notify their municipality or the Conservation Authority about any bluff failures that do occur."

In 2014 MVCA facilitated an erosion emergency exercise with Ashfield-Colborne-Wawanosh (ACW), a township located in Huron County. There are plans to do a similar exercise with Central Huron later in 2016. As currently higher lake levels and precipitation heighten the risk of bluff erosion, municipal leaders are increasingly concerned about the implications for their first responders (fire, police, ambulance, and hospital) and communities in the event of a bluff failure.

It is important to note that erosion doesn't usually happen in a regular pattern. A bluff described as having an average rate of erosion of 30cm per year may not erode 30cm every year. The bluff may not erode for several years, and then a large piece of bluff may break away. Hazard setbacks help to ensure that future development is not placed into a known risk area.

Once steepened to an unstable angle, bluffs can continue to erode even without wave action. Bluff slopes are always trying to reach a 'stable' angle. Along Lake Huron, that slope tends to be about 3:1(length:height). Steep slopes along the lakeshore can appear stable, but if development were to alter the slope, or remove its trees and other vegetation, significant erosion may occur.

The Question of Structures

Over the decades, there has been consideration of various engineered structures to address low water situations, most recently with respect to pressure by Georgian Bay cottagers for structures to hold back water in the Lake Huron/Michigan system. However, these have been approached with caution because of potential adverse down-coast impacts to important tourist areas, such as Grand Bend (one of Ontario's best beaches) and the Pinery Provincial Park. There could be negative economic as well as environmental impacts.

In addition, structures built to mitigate low water situations can exacerbate high water situations. For example, cottagers who bulldoze the dunes in front of their cottages to obtain a better view in

low water situations can find there is nothing preventing their cottages from being flooded in high water situations.

In bluff erosion situations, there have been a variety of structural approaches attempted to prevent erosion. Some of these are documented in Bluff Erosion Case Studies in the appendices.

Until recently, many believed that with careful planning, hard shoreline protection structures could be constructed without significant adverse impact to neighboring properties. However, recent research along the shores of Lake Michigan has demonstrated that this is not the case. Hard shoreline protection structures have been shown to more than double recession rates of bluff top and toe erosion in certain areas. (Grafton case study from the 2014 article by Bridget Faust and Jeffrey D. Stone, Association of State Floodplain Managers, in the Great Lakes Coastal Resilience Planning Guide, Communicating Long-Term Bluff Erosion to Prevent Unsustainable Development).

The 2013 Position Statement of the Lake Huron Centre for Coastal Conservation on Extreme Water Levels on Lake Huron, describes some of the consequences of structural approaches as follows:

> As a result of shoreline erosion and flooding situations during high levels, extensive structural protection measures were installed along the shoreline that provided temporary relief. In hindsight, many of the structures interfered with natural coastal processes and simply magnified the problem, or transferred the problem downshore. In one example near Grand Bend, Ontario, one cottage association claimed that their neighbouring cottagers upshore had installed protection structures that had the effect of altering coastal processes causing erosion to the cottage properties downshore. They successfully launched a lawsuit that required the removal of the structures. (pg. 5)

The *Cautionary Tales* case studies in the appendices provide similar U.S. examples of erosion liability. Nearer to home and most recently, Ethan Griesbach, project manager with the TRCA was quoted as explaining that, by building groins to protect a portion of the Scarborough Bluffs (see case study in Appendix 5), "We essentially started to starve the islands of a source of sediment to sustain itself." (Reference: Erosion could cause Gibraltar Point to split in two, says the Toronto conservation authority. Dan Taekema, Staff Reporter, Toronto Star, May 1, 2016.)

Goderich Erosion Control

In Huron County, the Goderich waterfront has undergone an extensive transformation since the mid 1980s. Historically the bluff at Goderich was one of the most erosive on the Lake Huron shoreline. Erosion rates were over one metre per year. Waves would be lapping against near vertical bluffs, in some cases. Erosion became a public safety issue, with the town's sewage treatment plant and a residential subdivision located at the top of the bluff.

The MVCA, along with the federal, provincial, and municipal governments, initiated an erosion control project using an approach that was unique for its time. It was based on the development of an artificial beach at the base of the bluff. The artificial beach, like natural beaches, would

protect the land from erosion. A 450 metre armourstone jetty was constructed out into the water to hold the beach in place. About 4000 tonnes of armourstone and rip rap were used in the construction of the jetty at a cost of about $150,000 (1980 dollars). The foundation material for the artificial beach was material that was dredged from the harbour.

Strong storms off the lake eroded portions of the new beach, and led engineers to design cigar-shaped structures composed of armourstone placed parallel to the shoreline at several locations along the shore, to "pin" the beach and prevent future erosion.

Once the coastal erosion had been eliminated by the artificial beach, key areas of the bluff were investigated to see what condition they were in. The bluff adjacent to the beach was determined to still pose a threat to residences at the top of the bluff. While coastal erosion had been eliminated, surface water and ground water continued to work to erode the bluff.

Another unique approach was undertaken by the MVCA in the early 1990s, by using a slope erosion control technique called soil bioengineering. This technique relies on plant biology, in combination with conventional measures. The oversteepened top of bluff was cut back, and the material used as fill at the base of the bluff to create a gentler slope angle overall. Then the slope was terraced so that living plant material could be installed onto each terrace and backfilled to bury the plant material. The plant cuttings from particular native woody plants were installed in specific ways into the slope face, including brush mattresses and fascines. The primary species used were: willow, red-osier dogwood, poplar, and sumac. About four acres of plant cuttings were used on this project. The use of woody plants is ideal in erosion control projects because the plants absorb and transpire large amounts of water, the plants slow down the flow of surface runoff, and the roots and the woody stems provide a strong binding mechanism and structure to the soil.

The soil bioengineering was completed in 1995. In addition, two storm sewers were constructed in 1993 at the top of the bluff to remove excess storm water from the project area. Since then, there have been suggestion of adverse downshore consequences of the Goderich erosion control initiatives, although this has not been quantified.

There is an enhanced appreciation of coastal dynamics and dune/erosion cycles in recent years, with increasing recognition of the complexity of Great Lakes cycles and the danger of unintended consequences from well-meant actions. In general, engineered structures are now rarely considered an appropriate response to erosion.

As engineered structures have proven problematic and ultimately ineffective, there has been an increase in regulatory approaches, such as that embedded in Ontario's land-use planning system, PPS and use of conservation authorities to ensure public safety in hazard lands.

Education and Engagement

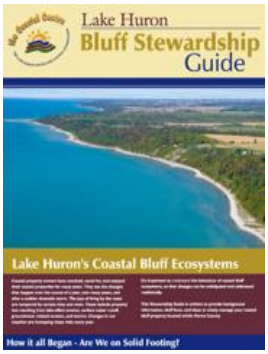
Recognizing that property owners need to understand what causes bluff erosion and why they should adhere to regulations, governments have issued guidelines, manuals, websites, and public meetings to provide useful information. An informed and engaged public is more likely to accept and participate in protection programs. However, such education needs to be continuous because of population turnover.

ABCA has had a shoreline management plan for over 20 years that has highlighted the risk along the shoreline; it is being updated in 2016. MVCA has identified the need for an education and outreach plan to help get information out to the bluff property owners. Both CAs have online mapping easily accessible to property owners, which shows 100-year erosion lines and stable slope areas for individual properties.

The LHCCC produced a self-administered erosion checklist for property owners to assess the stability of their bluff properties, as well as a Lake Huron Bluff Stewardship Guide.

Educating private property owners is an ongoing process that needs to be repeated every time a property is bought and sold. In Huron County, local authorities have noticed a marked increase in sales of shoreline residences each time lake levels peak and erosion becomes more noticeable. It is unlikely that the rate of erosion or land conservation are top of mind when a potential buyer is looking at his/her dream cottage overlooking a bluff. However, it becomes an issue once the new owner either wants to build on the property or notices waves washing away the bluff toe or tension cracks appearing in the yard.

Real estate agents may have a role to play since they are the first point of contact with buyers. Some, but not all, do advise prospective purchasers that a shoreline residence may have hazard land designation. Bluff erosion is a "known defect", so it is up to a home inspector to raise it, provided that a professional home inspection is done. However, disclosure of features affecting the property may be a safety issue as well as a matter of ethics. If a dangerous situation is not disclosed, the agent could be liable. This issue was noted as early as the 1993 IJC report, which recommended: "real estate disclosure requirements where the seller should be required to disclose to prospective buyers that the property is within a mapped or known flood or erosion hazard area. The buyer should sign an acknowledgement that he or she has been informed of the risk." (pg. 44)



Engaging the public through various means such as websites, manuals, and public meetings can work to empower property owners to take on protection of their bluffs, within acceptable parameters. For example, where applicable, owners can cost-effectively maintain and grow vegetation to stabilize their bluffs without the help of the local authority. Presenting objective, science-based demonstrations of the natural cycle of bluff erosion tends to increase the owners' understanding and trust in the regulations.

The Huron County WPSC January 15 workshop discussions identified significant issues around how to engage bluff homeowners and prospective homeowners in discussions and evaluation of

their property's erosion status, natural options to improve bluff stability and/or not increase erosion potential, and emergency procedures to take in the event of a slump, as well as ways to ensure full disclosure of the property's hazard land status at the time of purchase/sale. These are questions that will be further discussed during summer consultations.

Managed Retreat

There was also interest in further research and discussion of possible ways to help homeowners interested in considering a "managed retreat" of their home – moving the house or cottage to a new location further back from the edge of a bluff.

Where the bluff has eroded putting the home dangerously close to the edge, sometimes a managed retreat may be the best alternative. The most common examples are found along ocean coastlines, such as those in Maine and Atlantic Canada, but there have been Huron County property owners who have made the move to lift their homes off their foundations and move them away from the edge of the bluff. Managed retreat can be a costly proposition for the property owner, however, it may be the only way to save the house and continue using it on another lot.

During the high water levels of the 1990s, there was discussion of the need to plan for "runaway" lots to be established. These would be vacant lots delineated behind 'at-risk' lots so that when erosion becomes an imminent threat, there is a place to relocate the cottage. The idea never went further than discussion, but consideration could be given to identifying potential areas for residential relocations, should property owners be willing to pursue this option. It would provide some benefit to the homeowner, who would save the structure, while helping to maintain the municipal tax base and local economy, reduce liability, and ensure public safety.

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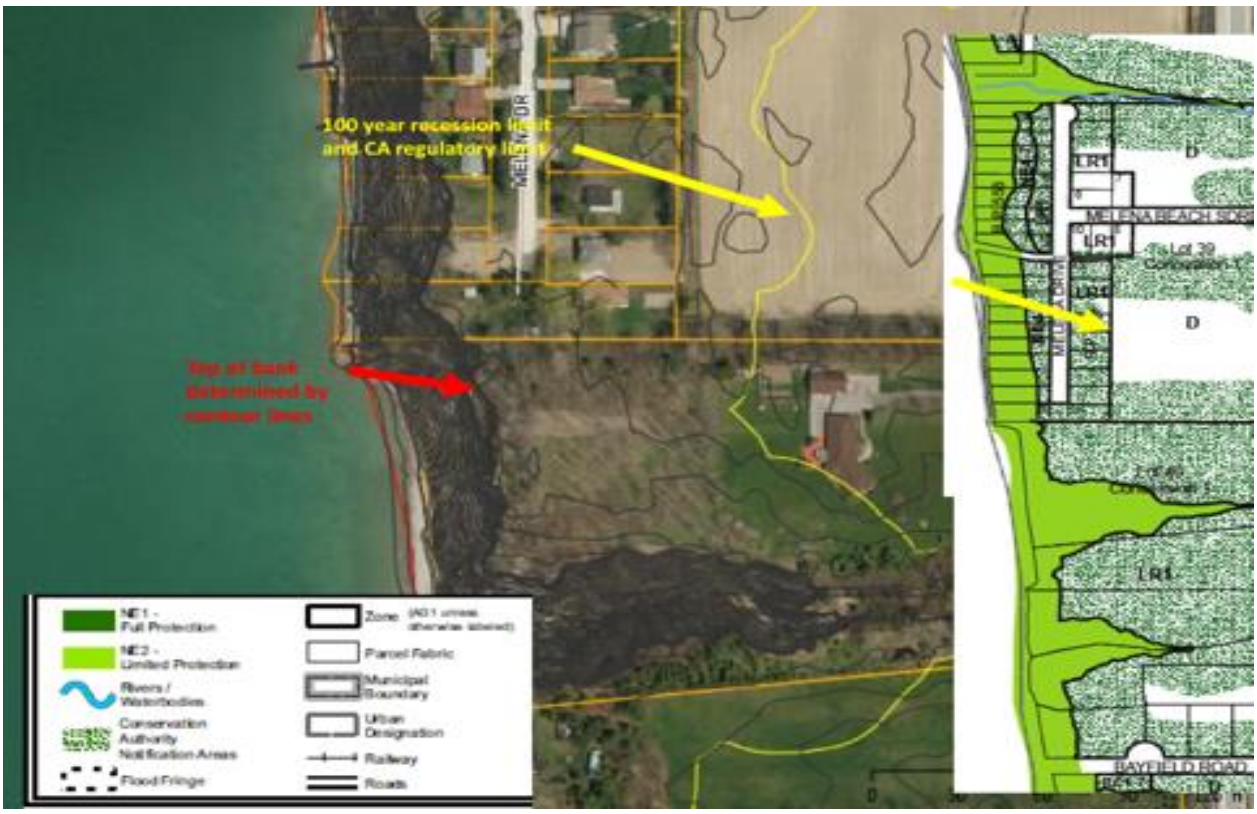

Figure 9: CA bluff erosion regulatory line and zoning, from S. Reid's January 15, 2016 Land-Use Planning presentation.

ADDITIONAL CONSIDERATIONS

Erosion prediction difficult

The lack of a reliable tool for predicting erosion presents a major concern to Huron County authorities. This is a public safety issue, as people may not be warned in time to exit their houses on the bluff before an event occurs.

Great Lakes water diversion

Concern about potential diversion of Great Lakes waters outside the watershed was raised by several of the subcommittee members, but it is not something that can be addressed locally. This concern is validated by the recent request from Waukesha, Wisconsin to divert water from Lake Michigan in order to restore its low and contaminated aquifer (Mehta, 2016). "Under a current regional agreement between eight US. states and Ontario and Quebec, diversions of water away from the Great Lakes-St. Lawrence River basin are banned, with limited exceptions that can be made only when certain conditions are met," (Mehta, 2016. p. A17). (See Appendix 3 for Toronto Star article and LHCCC article and links.)

Extreme lake levels study processes underway

In Huron County, several study processes are underway relating to extreme lake levels, which are serving to raise awareness among the public, will provide updated shoreline assessments and policies for decision-makers, and will lead to new programs and initiatives focussed on Lake Huron lake levels.

- ABCA is updating its Shoreline Management Plan, with public consultations underway and a final version expected in fall 2016. With the creation of a steering committee and consulting team, long-term erosion rates are being reviewed, shore processes assessed, shoreline protection evaluated, and policies reviewed.

- MVCA, responsible for most of the county's bluffs, is developing a public education strategy. MVCA already has detailed hazard land mapping available to the public on its webpage and emergency preparedness information for homeowners. In 2014, the MVCA facilitated an erosion emergency exercise with ACW. There are plans to do a similar exercise with Central Huron in 2016.

- The LHCCC is planning to develop a Coastal Action Plan. The non-profit conservation organization works with the MVCA and its shoreline municipalities providing shoreline management services to communities.

- Huron County's Water Protection Steering Committee celebrated its 2000th funded project for conservation and stewardship on March 28th, 2016.

- The Town of Goderich is working on a waterfront master plan for the area from the south side of the harbour (including the grain elevators) southward along the urban lakefront.

CONSULTATION INPUT (pending – Phase 2)

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APPENDICES

1. Lake Levels Projections under Climate Change Scenarios
2. Preliminary Retrospective Analysis (1995 to 2014)
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    - Great Lake diversion plan has Ontario concerned, April 2, 2016, Toronto Star
    - So, You Want to Take Our Water? e-newsletter March 2016, LHCCC
    - Weather disaster preparation gets federal cash boost, January 16, 2016 Toronto Star
    - Heightened risk of shoreline erosion, April 23, 2016, MVCA website
7. Project chronology
8. IA Team, Students and Huron County contributors
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Appendix 1 – Lake Levels Projections Under Climate Change Scenarios

MacKay and Seglenieks (2013) reviewed lake level projections for Lake Michigan – Huron illustrating a wide range of possibilities, but the median results show declines between 0.20 m to 0.45 m in lake level projections (Figure 1). They also used a new method of projecting lake levels by applying both a dynamic downscaling and a bias correction to the Global Climate Models (GCMs) they also projected a decline in Lake Michigan – Huron. However, they also noted an increase in the projected mean seasonal range (difference between annual maximum and minimum levels) of 4 cm for Michigan – Huron.

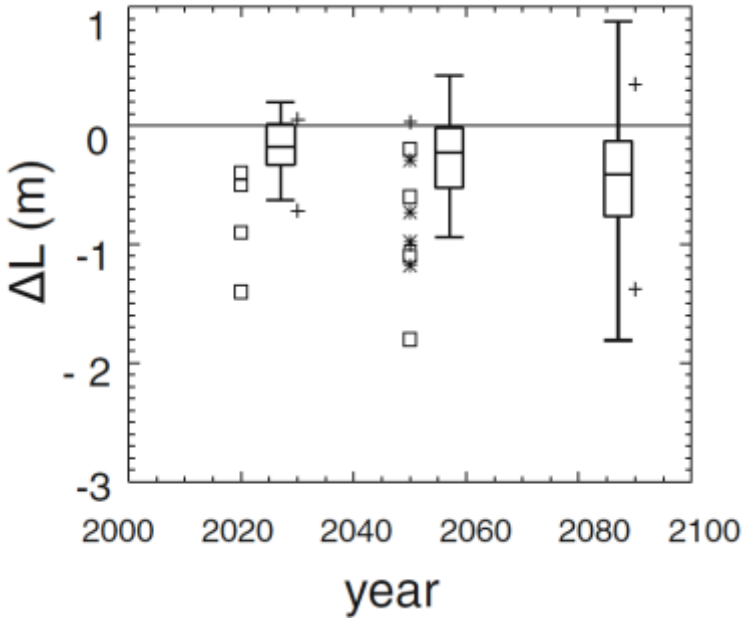


Figure 9. Simulated lake level changes (y-axis) for Lake Michigan-Huron from previous studies with box plot indicating the median, inter-quartile range, and the 5th and 95th percentile (reproduced from MacKay and Seglenieks (2013).

Reference:

1. MacKay, M., Seglenieks, F. (2013). On the simulation of Laurentian Great Lakes water levels under projections of global climate change. Climate Change, 117: 55-67.

Appendix 2 – Preliminary Retrospective Analysis (1995 to 2014)

Preliminary retrospective (1995 to 2014) analysis was performed using hourly data from the Canadian Hydrographic Service (CHS) for the Goderich station in Lake Huron to examine variability in lake levels across 10 time horizons ranging from hours to months. Wavelet analysis was used to decompose temporal patterns in variability for each of the 20 years (Blukacz et al. 2009). Annual variation was summarized using the slope from a log–log plot of wavelet variance as a function of time horizon, hereafter referred to as wavelet slope. For a given year, a positive wavelet slope indicates that lake levels mainly fluctuated on a monthly basis 21 to 43 days, while a negative slope indicates that variability decreased mainly with time and that lake levels fluctuated mainly on a daily to weekly basis. A horizontal wavelet slope, indicates that there were no dominant time-scales. Over the past 20 years, both positive and negative wavelet slopes were observed and there was no consistent pattern over the years, except that in recent years the overall variation tended to have a wider range, indicating that water levels showed more extreme events in lows and highs (Figure 1).

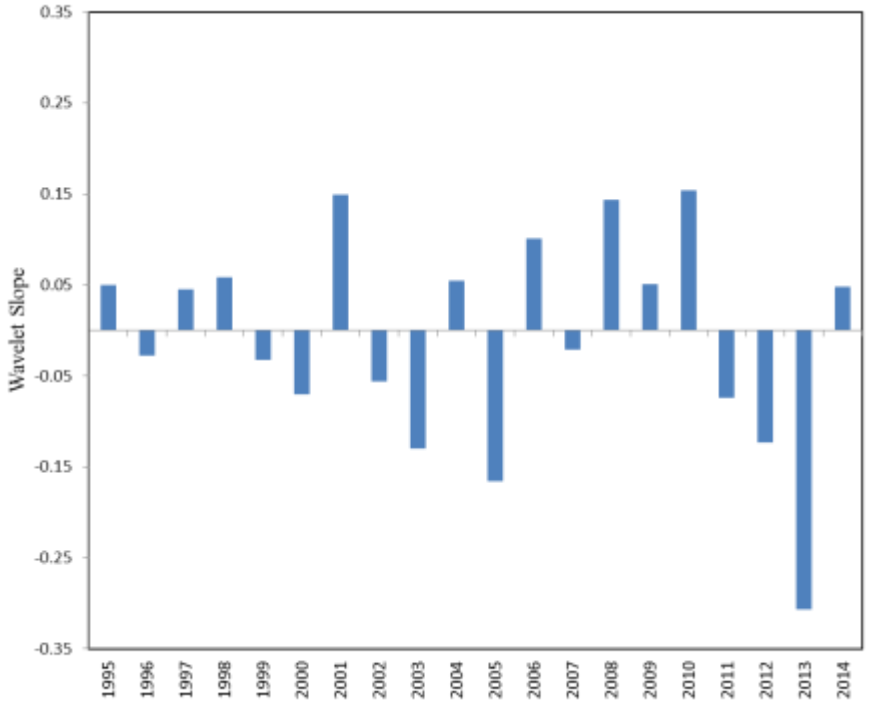


Figure 10. Water levels were analysed using wavelet analysis as described by Blukacz et al. 2009.

Reference:

1. Blukacz, E.A., Shuter, B.J., Sprules, W.G., (2009). Towards understanding the relationship between wind conditions and plankton patchiness. Limnology and Oceanography, **54**: 1530–1540.

Appendix 3 – Climatology Changes in Lake Huron – Michigan

Time series data were downloaded from the Great Lakes Environmental Research Laboratory (GLERL) dashboard and plotted for Lake Huron – Michigan. The lake levels over the last 15 years have decreased with changes ranging from 0.50 m increase to a 0.50 decrease (Figure 1 A, B). In 2014, lake levels have increased by about 0.50 m.

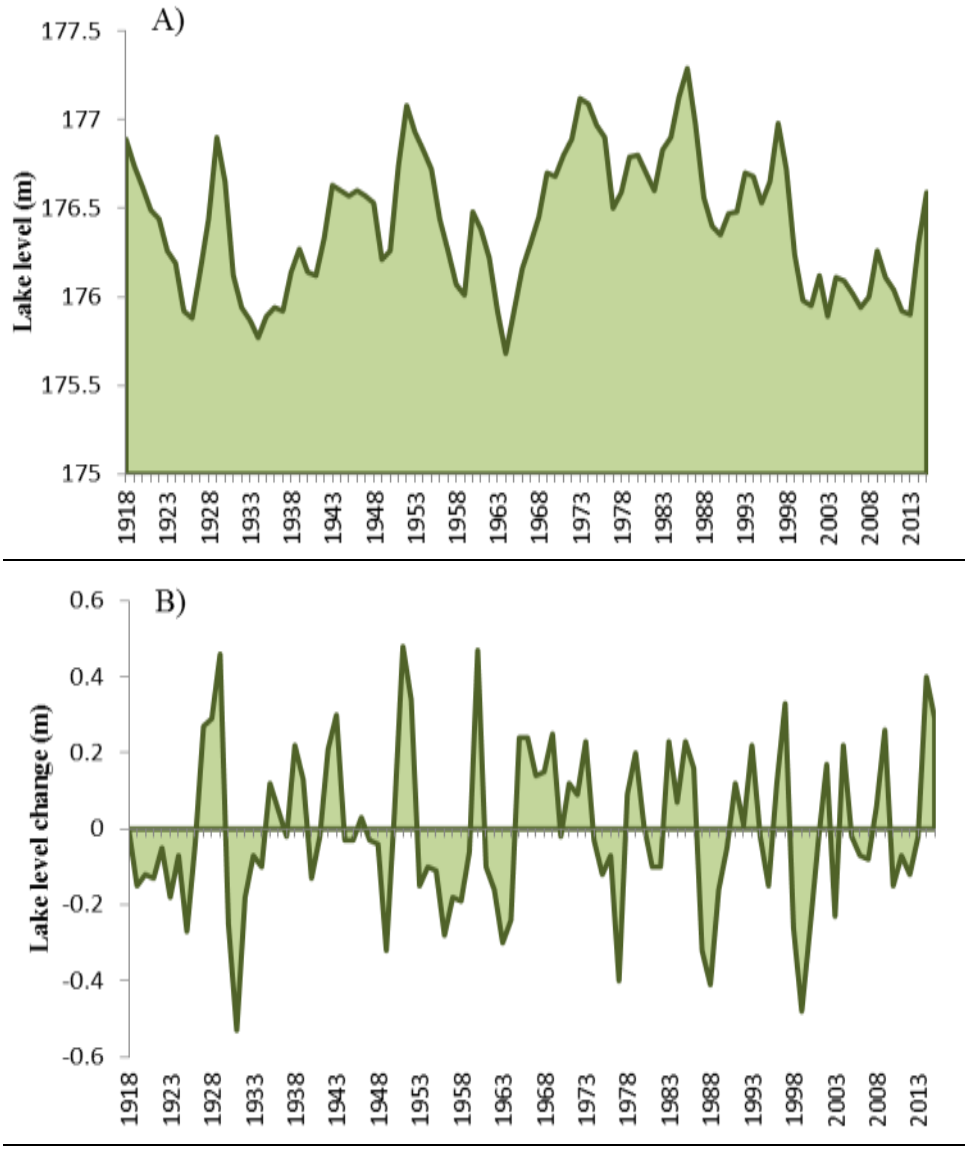


Figure 11. Lake levels (A) and changes in lake levels (B) averaged on an annual basis.

Over the past 15 years, there was an increase in runoff, precipitation, and evaporation (Figure 2).

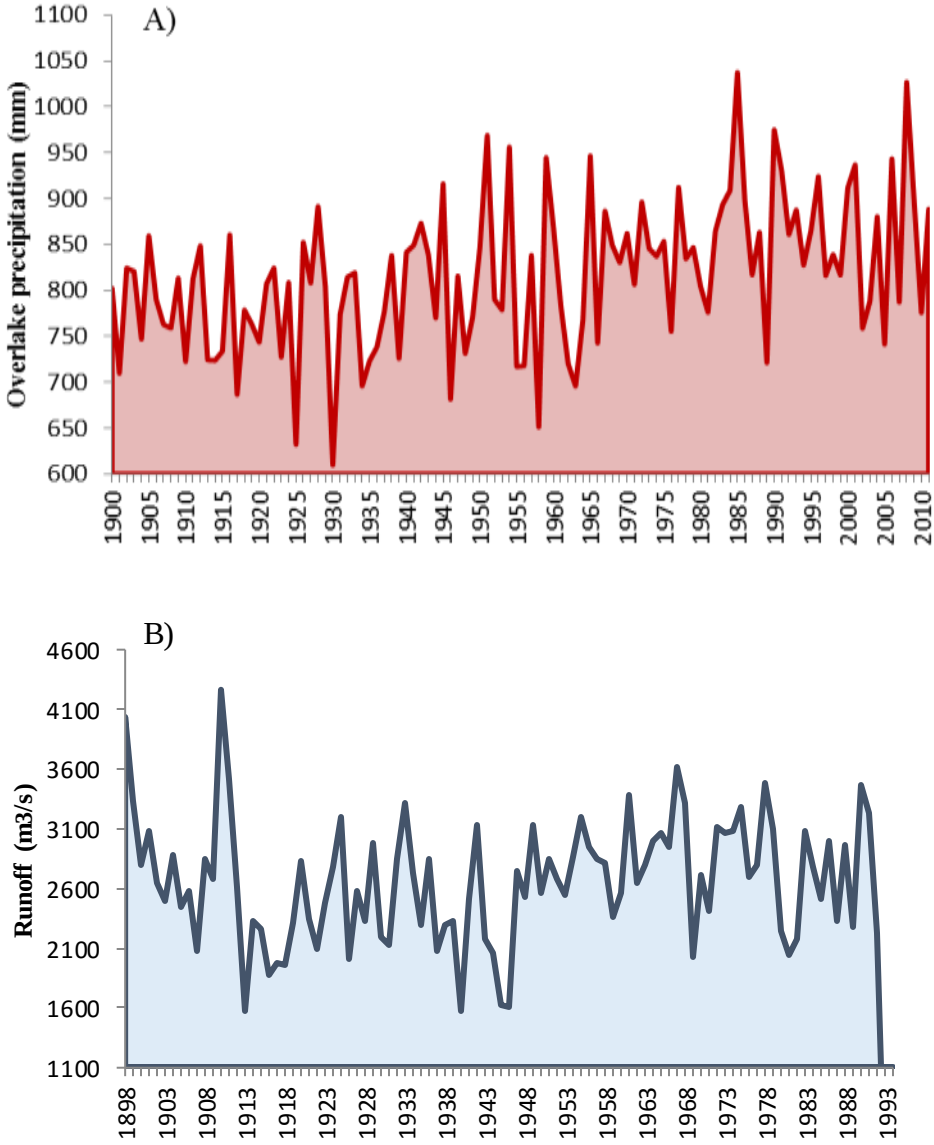


Figure 12. Overlake precipitation (A) and runoff (B) averaged on an annual basis.

Appendix 4: Canadian Regulatory Environment for Water

In Canada, governance of freshwater is a complex process that involves provincial and territorial governments. Federal or provincial legislation may apply depending on the type of water body and how water is used. Canada's provinces and territories are primarily responsible for most of the environmental regulation and policy development.

Across the federal government there are over 20 different departments (for example, Environment and Climate Change Canada; Fisheries and Oceans) with various responsibilities for freshwater.

Under the Canadian Constitution, the federal government has jurisdiction for fisheries, navigation, federal lands, and international relations, including responsibilities related to the management of boundary waters shared with the United States, including relations with the International Joint Commission (IJC). The federal government also has responsibilities for agriculture, aquatic research, and ensuring that standards and policies are in place.

Provincial governments are responsible for sewer and potable water service regulation, water quality, and most other environmental issues relating to water, with conservation authorities authorized to deal with natural hazards, while municipalities and conservation authorities implement federal and provincial legislation and policies through their by-laws, land-use planning, and service delivery functions.

Federal Water Legislation

Key federal legislation includes the *Canada Water Act*, which provides a framework for collaboration among the federal, provincial and territorial governments on water resources management. Reports published on an annual basis, summarize programs such as Environment Canada's Water Survey of Canada, which measure water flow and quantity across Canada and findings under major federal-provincial/territorial agreements used to manage water resources.

The *International River Improvement Act* ensures that Canada's water resources in international river basins are developed and used in the best national interest. Reports are published on an annual basis, that summarize operations on water flowing from international rivers in Canada to any place outside of Canada. The act provides licensing for river improvements such as dams, obstruction, canal, or other work that alters the flow of an international river into the United States.

The *International Boundary Waters Treaty Act* provides mechanisms for resolving water disputes between Canada and United States. The act was amended in 2001 to provide a more effective implementation by: 1) prohibiting bulk removal of boundary waters from the basins in which they are located, 2) requiring persons to obtain licenses from the Minister of Foreign Affairs for water-related projects in boundary or trans-boundary waters that would affect the natural level or flow of waters on the United States side of the border, and 3) providing clear sanctions and penalties for violation. Prohibitions of boundary water removals would apply to the Great Lakes, St. Lawrence River, the St. Croix and Upper St. John Rivers, and the Lake of

the Woods. A joint Canada-United States study by the IJC entitled, *Protection of the Waters of the Great Lakes (2000)* concluded that the Great Lakes require protection, from the uncertainties and impacts of removals, consumption, population and economic growth, and climate change.

The *Department of the Environment Act*, establishes Environment and Climate Change Canada (ECCC) as the federal department in Canada responsible for preserving and enhancing the quality of the environment which includes water, air, soil, and biota. An annual report must be submitted to summarize the operations of ECCC.

The *Navigable Waters Protection Act*, protects lakes, rivers, and oceans requiring approval for projects that may affect navigation in Canada. Additional Acts include the: 1) *Canadian Environmental Protection Act*, directed at reducing toxic substances in the environment, and 2) the *Fisheries Act*, which protects fish habitat from alteration or destruction.

Agreements

Under the *Great Lakes Water Quality* Agreement, Canada and the United States are committed to restoring and maintaining the chemical, physical and biological integrity of the water of the Great Lakes Basin ecosystem. The *Great Lakes Binational Toxic Strategy* between Canada and the United States maps out a path towards the virtual elimination of persistent toxic substances from the environment.

References:

http://www.nrcan.gc.ca/plans-performance-reports/sustainable-development/freshwater/601 (accessed March 21, 2016)
https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=E05A7F81-1#Section1 (accessed March 21, 2016)
http://www.ec.gc.ca/eau-water/A881B520-8661-4E08-B670-07EC3450A4F7/2013_IRIA-AR_eng.pdf (accessed March 21, 2016)
http://www.lop.parl.gc.ca/About/Parliament/LegislativeSummaries/bills_ls.asp?ls=C6&Parl=37&Ses=1 (accessed March 21, 2016)
http://canadians.org/node/3672 (accessed March 21, 2016)

Appendix 5: Bluff Erosion Case Studies

This section provides an overview of approaches to bluff protection or adaptation to erosion taken in various jurisdictions. It is intended to show different approaches, but not to endorse any single approach nor to assess the long-term success of the methods.

Constructing Hard Structures

Hard structures, such as rip-rap, groins, or breakwalls have been used in some jurisdictions to prevent undercutting of the bluffs. Installation of hard structures, require specialized engineering so that in preventing erosion in one area, the littoral drift is not interrupted or altered inadvertently by redirected waves. "These changes to the *overall sediment budget*, lead to the collection of sediments in some areas and sand starvation in others (along the coast) depending on current direction." (Sea Grant, 2013)

Case Study: Scarborough Bluffs – City of Toronto

The City of Toronto's work at the Scarborough Bluffs is a very recent example of the hard structure approach.

The City of Toronto is an urban municipality of approximately 2.86 million people located on Lake Ontario. The Scarborough Bluffs are located in the east end of the City. A unique feature, the bluffs are 57 m high with steep incline of 1:2:1. (horizontal: vertical).

Historically, the Scarborough Bluffs have been considered as a desirable residential area with high property values. All the properties are tied into city services (sewer, utilities, power). The bluff erosion had been monitored since 1985, and homeowners had approached the city repeatedly requesting repair and remediation. The area in question contains 16 private residences, including a heritage preservation building. Twelve of these residences were being directly affected by erosion. The erosion rate was approximately 1.2 to 1.8 m per year (2010 estimate using historic data).

In 2010 the Toronto Region Conservation Authority (TRCA) completed a multifaceted options report and undertook extensive public consultation on its recommendations. The analysis considered factors such as: public safety, aesthetics (park, public beach, walkway, and views), environmental impacts, current and future recreational uses (boating and water sports), and financial matters (affordability), and the value of public/private property loss versus cost of remediation.

The TRCA proposed various options for a 600 to1,400 m stretch along the bluffs. It also estimated the long-term cost of 'doing nothing'. Predicting erosion of the toe and crest at 1.2 to 1.8 m per year over 100 years, the cost of 'doing nothing' was estimated at $29.6 million (in 2009 dollars). This included the loss of private property, as well as the cost of moving infrastructure, utility, power and sewer lines.

After much debate, the local authorities decided to focus on 600 m where erosion was the

greatest. A cobble beach along the shoreline anchored by a series of parallel headlands (groins), which would protect 600 m of eroding bluff was proposed. The headlands, measuring between 80 to 100 m in length and spaced 100 to 150 m apart, were to be constructed with large (3-5 tonne) armour stones. The remediation was completed in late 2015 costing approximately $6.5 million (Scarborough Bluffs: $6.5 million erosion prevention project offers hope to those living on the edge, by Jeff Green, Toronto Star, April 22, 2013.

One of the objectives was to maximize public use by increasing the recreational potential of the area below the bluffs. In return for the municipality's involvement, the property owners ceded their riparian rights: " . . . the homes that line Meadowcliffe Dr. gave up something precious for it: their private waterfront" (Jeff Green, Toronto Star, April 22, 2013) The beach was built up with beach gravel and a walkway was constructed on beach below the bluffs to facilitate public access.

A May 1, 2016 article in the Toronto Star reported that to protect the Toronto Islands from further loss of their beaches, the Toronto and Regional Conservation Authority (TRCA) was planning to build a 550 metre breakwater. The TRCA attributes the erosion not only to natural causes – wind and storms; but also to the stabilization of Scarborough Bluffs (in 2015) and creation of the Leslie Street Spit (in the 1960's), which have accelerated the land erosion.

Ethan Griesbach, project manager with the TRCA was quoted as explaining that "We essentially started to starve the islands of a source of sediment to sustain itself." (Reference: **Erosion could cause Gibraltar Point to split in two, says the Toronto conservation authority.** Dan Taekema, Staff Reporter, Toronto Star, May 1, 2016.)

Explanatory Notes:

The Leslie Street Spit, or officially the Outer Harbour East Headland, is a man-made headland in Toronto, Canada, extending from the city's east end in a roughly southwesterly direction into Lake Ontario. It is about 5 kilometres (3 mi) long. The Spit is the result of five decades of lakefilling by the Toronto Port Authority. It was conceived as an extension of Toronto Harbour, and has evolved into a largely passive recreation area.

The Toronto Islands are a chain of small islands in the city of Toronto, Ontario, Canada. Comprising the only group of islands in the western part of Lake Ontario, the Toronto Islands are located just offshore from the city centre, and provide shelter for Toronto Harbour. The islands are a valued recreational area home to parkland, the island airport, a small residential community, several boat clubs, an amusement park and several sand beaches. They are located south west of the Scarborough Bluffs.

Bioengineering/Soft Stabilization

Bioengineering involves using live plants and plant parts to perform a structural function to stabilize bluffs or banks. The plants serve to reinforce the soil, improve water drainage, prevent erosion and dewater wet soils. Once the vegetation establishes, it works most effectively on the crest and face of a bluff.

In Canada and the United States, provincial, municipal, and state governments have produced guidelines and manuals for coastal property owners on planting vegetation and vegetation management. The manuals advise property owners on local regulations, the types of plants grow best on bluffs, slopes, and banks, and how to care for the vegetation. Indigenous plants are suggested to prevent propagation of invasive species.

In the Lake Tahoe Basin, Nevada, the University of Nevada has done extensive experimentation of different grass mixes, which both control soil erosion and are fire resistant. The Tahoe Regional Planning Agency has issued a detailed guide recommending plants and grasses, including turf and erosion control grasses.

These manuals or guidelines are predicated on the expectation that private property owners are knowledgeable and engaged in shoreline protection. Onus is on the property owners to plant and maintain the plant materials.

Where there are sensitive coastal areas many local governments have included an environmental protection component in their local by-laws and ordinances in addition to stringent site regulations. The city of San Diego, California for example has included a requirement for use of native plants for bluff stabilization in its Land Development Code.

South Haven, Michigan: case study

Property Owners in the town of South Haven, on Lake Michigan, whose homes were situated on a 37 metre, highly erodible clay loess bluff, took on such a challenge. Their bluff was eroding through seepage, water flows, and high-velocity surface run off. In addition, stairs anchored to the bluff from its top to the beach, were weakening the bluff's face. As the bluff was set back, there did not appear to be significant undercut damage.

Three companies were hired to: cut back the upper portion of the slope to a 1:1 gradient; and to tier/terrace the lower portion at 8 to 10 foot intervals with 4 to 5 foot benches (plateaus). A cellular confinement system made of polymer mesh was installed for lateral drainage. Mats composed of netting and coconut fiber were placed on the terraces for reinforcement, and a rolled sediment filtration device was installed to filter runoff water.

Rolled sediment filtration devices and turf-reinforcement mats were used to build and stabilize the terraces.

Within weeks of the project's completion, the native seed mix was returning the bluff to a natural vegetated condition.

Figure 13: photos of terracing approaches to bluff erosion, South Haven, Mich.

A total of 26 terraces were built. The terraces were filled with loamy topsoil and seeded with native annuals, perennials, grasses and shrubs. Protected with the coconut-filled turf reinforcement mat, it took approximately 6 months for the vegetation to establish itself.

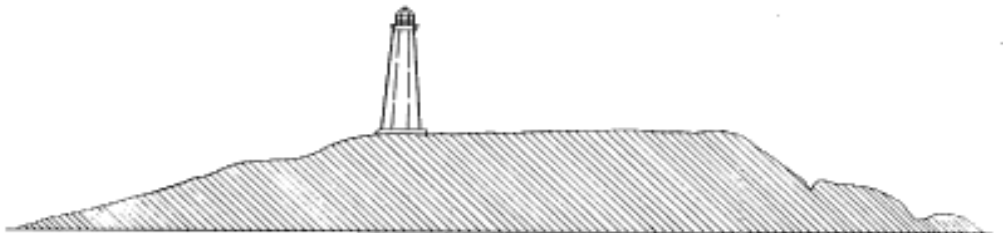
Integrated Bioengineering

Where there is a sharp degree of wave undercutting action as well as run-off from the top of the slope, some areas have implemented integrated bioengineering (biotechnical stabilization). A combination of plants, geotextile fabrics, and hard structures have been used to shore up the bluffs.

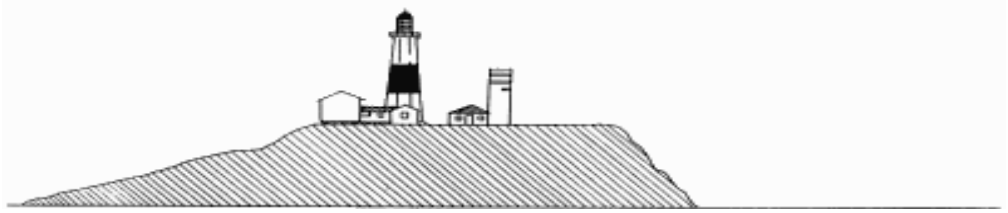
Montauk Lighthouse Point: case study

The Montauk Lighthouse is located on the Atlantic Ocean, in Montauk Point State Park on Long Island, New York. It was built in 1796 by Order of the second US Congress, signed by President George Washington. It is an important historic site for education and site tours on American history. The park's beach also supports water recreation.

The lighthouse commands a shoreline 274 metres long and stands on a 21-metre-high bluff. Over the last 200 years, erosion has claimed approximately 61 metres of shoreline.



1938 - Montauk Point (vertical section, west to east. Lighthouse was 220 feet (67 metres) from the bluff. 1838 United States Coastal Survey.



1990 – Montauk Point (vertical section west to east) Lighthouse is 100 feet (30.5 metres) from the bluff.

Figure 14: Montauk Point 1938 and 1990

Since the 1940's there were several efforts to stabilize the bluff with hard structures (a revetment, a seawall, and gabions). In the 1970's, over a period of 15 years, a group of private volunteers constructed, and, in large part financed, a bioengineered rehabilitation. They built filter box terraces filled with grasses and reeds, as well as constructing a revetment of boulders to protect the toe.

By the 1990's the bluff was, once again, deteriorating. Challenged with the decision of whether or not to move the lighthouse, the US government recognized "that unacceptable cultural and historic impacts would result from loss of historic property to structures in the vicinity of the Montauk Lighthouse." (Feasibility Study, October, 2005). The lighthouse was deemed too fragile to move, so the federal government funded the same method of rehabilitation. At a cost of $13.7 million the drainage system, filter box terraces and revetment were rebuilt. It is estimated that this will protect the bluff for another 73 years.

A cautionary tale: Grafton, Ozaukee County

An example on the U.S. side of erratic bluff erosion can be observed in the Village of Grafton. Located within Ozaukee County, this rural coastal town has had many homeowners face catastrophic bluff erosion overnight. In 2006, a home owner watched a significant portion of the bluff began to slump downward. Over the course of just a month feet of bluff were gone taking with it trees, a functioning septic systems, and a fence. At the cost of the homeowner, a major restoration project was completed in which the bluff was re-graded and vegetated. Less than a year after the bluff restoration was completed a second slumping episode occurred, taking with it approximately 80% of what had been restored. Events like this are not unique to one property owner, one bluff, or one town. Unsustainable development along the bluff tops is a pervasive problem throughout the Great Lakes coastal region.

Another cautionary tale: Concordia University, Michigan

While bioengineering can forestall bluff erosion, it is always dependent on the delicate balance of nature. Despite sophisticated engineering, erosion can still be unpredictable. Once completed, a project can still have detrimental effects in other areas and be subject to litigation.

This was the situation of the Concordia University located directly on bluffs over Lake Michigan. In the 2000s the university undertook an ambitious bioengineering project to prevent erosion of its bluffs and to refurbish its campus.

The university appeared to "do everything right" in the rehabilitation. It hired engineering and landscaping experts. The project adhered to all zoning and building controls. The university consulted and received feedback from its neighbors, since the project involved planting on the top and slope of the bluff, creating a wetland to capture runoff and constructing a revetment to impede undercutting of the bluff toe.

Once completed, the project was heralded as an environmental and design triumph. In 2009 the university won two prestigious landscaping and engineering awards. Videos were shot featuring the renovated campus as a marketing tool aimed at potential students.

Yet, by 2011, two adjacent neighbors had started litigation proceedings contending that because of over-engineering, the project had redirected the littoral drift and almost completely eroded their beaches. After two and a half years in court, an Ozaukee County jury agreed unanimously that the stone revetment caused significant harm to the neighboring properties. There was no award for damages because the jury did not find that Concordia University was negligent or that

it had intended or expected the nuisance. In the aftermath, Concordia University has been left with the decision of whether or not to make private arrangements with the affected neighbors.

Policy and Planning Techniques: Policy Statements

In recent years, governments have increasingly recognized the impacts of climate change, pressures of unsustainable development, and the potential for absolute loss of sensitive ecological sites.

In response, higher order governments (provinces and states) have passed policy statements and legislation regarding conservation of sensitive areas, including bluffs. In many instances, they have also created agencies (for example, Conservation Authorities in Ontario) to oversee adherence, among other conservation functions. Guided by these policies and regulations some local governments responsible for controlling land use and built form within their jurisdictions have included policies and codes/by-laws regarding use and conservation of bluffs and beaches.

Policies express a long term blueprint for dealing with erosion. They may address a single area or extend across several municipalities. The policy development debate allows the politicians to consider the value of remediation of a bluff in context of other their priorities (environmental, recreational, historic, and financial). They provide a framework for monitoring and collecting data to support coordinated decisions.

Policies delineate the responsibilities of the local authority, municipal government/s and those of private landowners. On their basis, local authorities establish municipal codes/bylaws as well as initiate public education, debate and collaboration with property owners on the value of the bluffs for the present and future.

Between 2000-2004 the province of Quebec studied the impacts of climate change and erosion along the Gulf of St. Lawrence evaluating the vulnerability of coastal communities. It was found that the coastline was not eroding at the same rate. The most significant impact was in the City of Sept Iles, where erosion was claiming eight metres per year. Earlier attempts to prevent erosion with traditional hard structures were not successful. Recognizing that action was required an intergovernmental technical committee (comprised of the provincial representatives, the regional county municipality, and the city) began to develop a 25-year Master Plan for coastline intervention to deal with coastline erosion and management problems.

Policy and Planning Techniques: Municipal Codes/By-Laws

Municipal codes/by-laws are the practical expression of the policy goal to control land uses that have a detrimental effect on bluffs. Generally, they address aesthetics, public safety and security by specifying setbacks and permitted/prohibited uses. They are also intended to prevent actions by private landowners, such as one-off remediation on an individual property, which could have unexpected consequences on different areas of the bluff or beach.
Some municipalities address only land use controls in their codes/by-laws while others are more comprehensive.

After extensive consultation with Island residents, in 2015 the local Council of Bainbridge Island, Washington (on Puget Sound) approved its Municipal Code based on policies expressed in its Shoreline Master Program. Both the Shoreline Master Plan and the Municipal Code address not only zoning, setback and building controls but also specifically prohibit use of hard structures in shoreline and bluff stabilization. For soft stabilization permitted types of vegetation are specified.

Appendix 6: Media and Press Releases

From November 3, 2015 London Free Press. Article by Debora VanBrenk.
"Lake Huron has gone from record-low levels to near record highs"

"The beaches, bluffs and harbours of Huron County might well become a proxy for much of the Great Lakes as University of Toronto researchers study the complex local effects when lake levels rise and fall. In just two years, Lake Huron has gone from record-low levels to near-record highs; from high-and-dry docks to eroded cliff faces, in a fluctuation that normally would take a decade or more.

"The biggest concern is the speed at which the change happened," said Central Huron Mayor Jim Ginn. "If the water levels get too low, shipping out of Lake Huron is impeded. The bigger issue for us is high-water levels. . . It's a substantial amount of property value and also a risk to life should one of the banks collapse."

So when Huron County was asked to throw some committee support behind a research study on the broader impact of changing lake levels — using the Goderich area as an example — Ginn was all for it.

Huron County council is expected to approve that step Wednesday.

Project leader Lynne Peterson said the research team hopes to enlist the support of municipalities and residents in a comprehensive look at how high/low lake levels affect a community's environmental, economic and social life.

Huron County is a good case study, she said, because it has "a little bit of everything" in a relatively small area: intense agriculture, dunes, bluffs, a commercial harbour, fisheries, tourism, cottages and lakeside homes.

The group is awaiting final word later this month on a grant from the Graham Sustainability Institute at the University of Michigan and on a grant application from the Rural Ontario Institute. After that, researchers hope to have a preliminary report by next spring and a final report in about a year.

In 2013, after several seasons of drought and warm weather, Lake Huron's levels dropped to their lowest since record-keeping began almost a century earlier.

Shipping companies reduced the weight of their loads so that they could navigate shallow channels; wetlands near shore dried up; and beach-goers luxuriated in wide beaches. Some groups suggested multimillion-dollar structures be built in the St. Clair River to moderate the flow of water from the lakes.

This year, following a wet autumn and cold winter and wet spring, Huron rose to levels almost matching the highs of the mid-1980s.

Erosion began carrying away bluff edges; shippers could again trust depth charts; and beach-goers found their once-expansive sandy playground had shrunk to mere metres wide.

Whether the cycle is a natural fluctuation or a function of climate change, or a combination of both, the changes will influence how communities all along the Great Lakes' coasts — in Canada and the U.S. — conduct business, grow agriculture, keep residents and attract visitors.

The lake changes will also affect local and provincial policy-making about environmental issues, said Peterson. With 120 kilometres of lakeshore, "we need to get a handle on what is behind what is happening so we can adapt to it," said Huron County Warden Paul Gowing."

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April 7, 2016
FOR IMMEDIATE RELEASE

More research, better data required to understand and adapt to climate impacts on the Great Lakes. New report from CGLR and Mowat Centre says uncertainty about future water levels and gaps in data affect climate adaptation decisions.

Toronto and Cleveland – Effectively adapting to changes in Lake Michigan-Huron water levels requires more research, balancing competing interests and a stronger adaptive management approach, says a new report from the Council of the Great Lakes Region (CGLR) and the Mowat Centre.

"Water levels in the Great Lakes are in a constant state of flux, and there is a lot of uncertainty about future trends," said Mark Fisher, president and CEO of the Council of the Great Lakes Region, a binational organization working to find new ways of accelerating economic growth in the region safely and sustainably. "So if we want to make the best decisions about adaptive measures, and how they will affect local communities, we need to strengthen the data we have available."

The first decade of the 21st century saw some of the lowest water levels on record across the Great Lakes, especially in Lake Huron and Georgian Bay. Concern over low water levels prompted calls for interventions to mitigate these fluctuations or even manage water levels across the Great Lakes through a series of new strategically placed dams. A 2014 report from CGLR and Mowat calculated that if extremely low water levels persisted until 2050, the adverse effects on the Great Lakes economy could reach $18.82 billion (USD).

"Water levels have actually risen in recent years, underscoring the unpredictable nature of the Great Lakes water system in rapidly changing conditions," explained Fisher. "Our new report's findings highlight the fact that gaps in currently available data may limit our public decision-making on how to respond to this reality."

The report set out to assess the costs and benefits of the three commonly proposed responses to fluctuations in Great Lakes water levels: building dams or other water-controlling structures to restore historic water levels in Lake Michigan-Huron and especially Georgian Bay; creating a system of water-controlling structures to manage water levels throughout the Great Lakes system; and adaptive management, which entails finding new and better ways of adapting to changes in water levels informed by bi-national monitoring, modelling and assessment of hydrological trends and impacts.

But researchers soon found that available data did not allow for a credible quantitative analysis of all three approaches and their economic impact across the region. A credible economic analysis could only be carried out on restoration through previously-studied water-controlling solutions, some of which date back to early and mid-20th century, and only in the context of

Lake Michigan-Huron. Updating older data and using conservative economic assumptions, the report found that restoring historic water levels in Lake Michigan-Huron using such engineering solutions, after factoring in the cost of these solutions, could yield a benefit of up to $250 million (USD) by 2064.

The report concludes that it is imperative to significantly improve and update the data available to officials deciding on responses to climate change. It recommends that governments support and strengthen the adaptive management system proposed in recent years by the International Joint Commission, the binational body charged with helping resolve disputes over the management of water bodies shared between Canada and the United States.

"Great Lakes decision-makers must navigate a politically complex environment in which some interests benefit while others perceive to be on the losing side," says Fisher. "Stronger data is essential for decision-makers to get the balance right."

The Council of the Great Lakes Region (CGLR) is a binational member-based organization that works to enhance regional collaboration and cross-border integration by bringing together stakeholders from the private, public, and not-profit sectors to advance effective, coordinated, and broadly shared responses to the region's common economic and environmental challenges while enhancing the well-being of its citizens.

The Mowat Centre is an independent public policy think tank located at the School of Public Policy & Governance at the University of Toronto and Ontario's non-partisan, evidence-based voice on public policy. It undertakes collaborative applied policy research, proposes innovative research-driven recommendations, and engages in public dialogue on Canada's most important national issues.

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Toronto Star, April 2, 2016, page A17

"Great Lake diversion plan has Ontario concerned"
by Diana Mehta of the Canadian Press.

"Ontario has "a number of concerns" with a Wisconsin city's request to draw water from the Great Lakes in what would be a precedent-setting move if the plan were approved.
Waukesha, a city of about 70,000, has asked the Great Lake states for permission to divert water from Lake Michigan because its own aquifer is running low and the water is contaminated with high levels of naturally occurring, cancer-causing radium.
Under a current regional agreement between eight US. states and Ontario and Quebec, diversions of water away from the Great Lakes-St. Lawrence River basin are banned, with limited exceptions that can be made only when certain conditions are met.
Waukesha, in seeking to become the first such exception to the ban argues that although it's located outside the boundary of the Great Lakes basin, it is part of a county straddling that geographical line and should be allowed access to the lakes' water.
But Ontario has taken issue with the plan in a technical review of the diversion application put forward by Waukesha and the Wisconsin department of natural resources.
"The Government of Ontario has identified a number of concerns relating to Wisconsin DNR's explanation of how Waukesha satisfies the 'straddling county' exception," wrote Jason Travers, director of the natural resources conservation policy branch at Ontario's ministry of natural resources.
The province also found that the potential effects of the proposed diversion on Great Lakes water quantity had not been sufficiently assessed.
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"So, You Want to Take Our Water?"
article by Geoff Peach, Coastal Resources Manager, Lake Huron Centre for Coastal Conservation, e-newsletter March 2016

Diverting water from the Great Lakes is a threat that governments have tried to curtail, but a recent request for a diversion has been made by Waukesha, Wisconsin. The city currently gets its water from groundwater sources, but the water contains naturally occurring radium that exceeds federal guidelines. As a result, the city has been ordered to find a solution to its water issue. One of the options they are considering is to divert water from Lake Michigan. The problem is, they are outside of the Great Lakes watershed, but technically within a county that straddles the watershed boundary.

In accordance with the 2005 Agreement signed by the Great Lakes Provincial Premiers and State Governors, the State of Wisconsin submitted the City of Waukesha water proposal application to the Great Lakes–St. Lawrence River Water Resources Regional Body on January 7, 2016. The application asks for permission to divert up to an annual average of 10.1 million gallons (38.2 million litres — the equivalent of 2 Olympic size swimming pools) of water per day from Lake Michigan. Waukesha is located outside the Great Lakes Basin but within a county that straddles the basin boundary. As a result, the diversion potentially qualifies for a 'straddling county' exception to the ban on diversions under the Agreement.

A study by several environmental non-government organizations from the State of Wisconsin concluded that Waukesha can use its existing deep and shallow water wells to provide ample clean and healthy water to their residents now and in the future if they simply invest in additional water treatment infrastructure to ensure the water supply meets state and federal standards going forward. The Non--Diversion Solution has been estimated to cost half of what a Great Lakes water diversion project would cost.

Ontarians have an opportunity to comment on the Waukesha proposal through the Regional Body's public participation process. A two-month public comment period began on January 12, 2016 and will close on March 14, 2016. Only comments received within this time period will be considered by the Regional Body.

More Information on this proposal:

- Wisconsin Department of Natural Resources review.
- CKNX – Diversion may not be necessary

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"Weather disaster preparation gets federal cash boost"
Jim Bronskill, The Canadian Press, Toronto Star, January 14, 2016
"Monies to be set aside to ensure communities can deal with floods, droughts, storms"

OTTAWA – The federal public safety minister says the government will open its wallet to help Canadians prepare for natural catastrophes spawned by extreme weather linked to climate change.

Devoting a portion of planned infrastructure spending to disaster readiness will not only stimulate the economy, but ensure communities are better able to deal with floods, forest fires, drought and ice storms, Ralph Goodale said in an interview with The Canadian Press.

"Weather events are going to get more severe, they're going to get more damaging," Goodale said.

"This is a very costly set of risks that are arising all of the time".

As part of its multibillion-dollar commitment to invest in a variety of infrastructure projects, the Liberal government has promised to spend moneyh on climate-resilient public works.

That could mean building floodways and dikes to eliminate or reduce damage from a swollen river, constructing tornado-safe rooms or buruying electrical cables to prevent ice buildup.

In recent years, parts of the Prairies have experienced severe swings, from flooding to drought and back again, "obviously flowing from the consequences of climate change," Goodale said.

"What kind of infrastructure do we need to put in place to be more effective in dealing with the problem of too much water one year and too little water the next? It presents an interesting challenge, but also an interesting set of opportunities in terms of economic development and growth."

Goodale's mandate letter fro Prime Minister Justin Trudeau directs him to work with the provinces and territories, indigenous peoples and municipalities to develop a comprehensive action plan that allows Canada to better predict, prepare for and respond to weather-related emergencies and natural disasters.

"There's a wealth of knowledge and ability. At the moment, it's not very well co-ordinated." Goodale said. "So you've got to get all different orders of government working together here."

Despite the upfront costs, mitigation measures have yielded significant savings in Canada and worldwide, Public Safety officials have pointed out. For example, as of 2012, the Red River Floodway, built in the 1960s at a cost of $60 million, had been used over 20 times and prevented some $30 billion in damages.

The remoteness of indigenous communities, aging infrastructure on reserves and lack of money for emergency preparedness make these settlements more vulnerable to natural disasters, say internal Public Safety notes disclosed under the Access to Information Act.

One measure of a community's readiness is the ability of critical assets – such as water, power and communication grids – to recover quickly from a catastrophe.

But departmental officials are working to come up with a comprehensive set of "indicators of vulnerability and resilience." This will identify high-risk areas in advance of disasters as well as the kinds of adverse events that severely strain a community, says an internal policy paper.

Without reliable measurements, "It will be difficult to tyarget programs and resources to 'bake resilience in' or to demonstrate the benefits of doing so," the paper says.

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“Heightened Risk of Shoreline Erosion”
April 23, 2016, MVCA notice on its website

Maitland Conservation is advising shoreline municipalities and residents of a heightened risk for bluff collapse and gully erosion along the Lake Huron shoreline. There are several factors contributing to this risk.

Although temperatures have been fairly mild, it has been quite a wet winter. Maitland Conservation staff report that the 30-year average for January to February rainfall is 30 mm and the average snowfall is 100 cm. In 2016 the watershed received an average of 63 mm of rain and 120 cm of snow. Mild winter temperatures have resulted in several freeze-thaw cycles over recent weeks so rain has been falling on unfrozen ground.

These two factors have saturated the land and softened the clay till bluffs making them more unstable. This can lead to slope failures along the shoreline and increased gully erosion.

In addition, lake levels are forecast to be higher this year as compared to 2015. High wind and wave action could erode the base of the bluffs in some areas.

"Bluff failures are very unpredictable in terms of when they will happen, or how extensive they will be," reports Stephen Jackson, Flood and Erosion Safety Services Coordinator with Maitland Conservation. “It’s important that landowners be aware of the risk and have a plan in place in case of a significant failure.”

Maitland Conservation would like to remind shoreline residents that there are inherent risks associated with development along Lake Huron. Bluff erosion is a natural process along the lake that needs to be recognized and respected. Maitland Conservation provides information on bluff and gully erosion, and shoreline regulations, to landowners and municipalities. Landowners are encouraged to notify their municipality or the Conservation Authority about any bluff failures that do occur.

For information contact:
Jayne Thompson, Communications Coordinator
Maitland Valley Conservation Authority
jthompson@mvca.on.ca

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Appendix 7: Project chronology

October 20, 2015: Huron County Integrated Assessment proposal submitted to Graham Sustainability Institute.

October 21: Planning and Development Committee of Huron County votes to recommend Huron County Council endorse use of the Huron County Water Protection Steering Committee (WPSC) as an interdisciplinary advisory committee for the Integrated Assessment project. (See table of WPSC members and affiliations below).

November 4: Huron County Council approves motion by Central Huron Mayor Jim Ginn, to send letter of support for the IA project to the University of Michigan, and to endorse the use of the county's Water Protection Steering Committee as the project's advisory committee.

November 24: IA proposal approved by Graham Sustainability Institute.

November 27: project kick-off presentation to Water Protection Steering Committee

January 15, 2016: full day workshop on lake level issues with Water Protection Steering Committee members. Committee establishes an Extreme Lake Levels subcommittee.

January 26 & March 3: Lynne Peterson and Agnes Richards teleconferences with Graham Sustainability Institute and other IA teams re progress, limitations of modelling approaches

April 1: Meeting with the Extreme Water Levels subcommittee of the Water Protection Steering Committee to review draft Phase I report, discuss summer consultation opportunities.

April 4: Draft Phase I report submitted to Graham Sustainability Institute for review
May 3: Phase I report submitted to Graham Sustainability Institute

Summer consultation sessions:
May 14: Presentation and discussion at Ashfield-Colborne Lakefront Association annual meeting

May 17: Meeting in Ann Arbor, Michigan, with Graham Sustainability Institute staff and IA advisory committee members

May 27: Presentation and discussion at "Is the Coast Clear" conference in Port Elgin. Consultation engagement.

June 10: Presentation and discussion at Bluewater Shoreline Residents' Association annual meeting. Consultation engagement.

Others tba

Appendix 8: IA Team, Students and Huron County Contributors

RESEARCH/PROJECT TEAM		
Name	**Area of Expertise**	**Role/ Project Contribution**
George Arhonditsis	P.I. University of Toronto	Project sponsor
Lynne Peterson	P.I. Project lead, integrated policy development	Project management, report writing and editing, presentations and consultation
Agnes Richards	Scientist, Environment Canada; and Adjunct Professor, University of Toronto	Canadian federal legislation and program environment, presentation and report content; project finance management.
Tanya Wanio	Policy development, municipal finance and land-use planning	Bluff erosion case studies; presentation and report content.
Helen MacRae	Policy development, municipal administration and economic development	Economic development, harbor issues, tourism issues and options. Presentation and report content
Kate Procter	Writer, editor, Huron County Farmer	Writer, report editor, researcher
Students		
Meghan Allerton	Student and Research Associate, University of Toronto, Ecological Modelling Laboratory	Impact of lake levels on commercial shipping, presentation and report content
Jocelynne Hudgins	Student and Intern, Elmira College and University of Nipissing (tbc)	Logistics, research and meeting support
Huron County experts and contributors		
Jim Ginn	Mayor, Central Huron, and Chair of the Water Protection Steering Committee	IA water levels meeting chair, project support
Susanna Reid	Planner, Huron County Planning and Development Dept.	Shoreline land-use planning policies and process, presentation and report content
Nina Reynolds	Huron County Planning Dept. Meeting logistics and project support	Meeting facility booking, WPSC and Extreme Water Levels subcommittee group contact.
Geoff Peach	Lake Huron Centre for Coastal Conservation, Project Director	Conservation and stewardship resources, policy papers on climate change and lake levels
Stephen Jackson	MVCA, Project development, Flood and Erosion Safety Services Coordinator	Bluff Erosion: Public Safety and Emergency Planning, presentation
Alec Scott	ABCA, Manager of Water and Planning	CA Regulations and Shoreline Management Planning, presentation

Appendix 9: Water Protection Steering Committee & Extreme Lake Levels Subcommittee

WATER PROTECTION STEERING COMMITTEE	
The Water Protection Steering Committee was established in spring 2004 with 3 goals: • To bring together representatives of agencies, groups and municipalities (including Planning, Health Unit, Municipalities, Conversation Authorities, MOE, OMAF, agriculture, manufacturing, tourism, cottage associations, watershed groups, etc.) • To prioritize and recommend implementation measures to participating agencies • To coordinate activities at a broad level, subject to the resources of the participating agencies	
Agency/ Organization	**Representatives**
County Council	Jim Ginn (chair) Maureen Cole (South Huron) Art Versteeg (Howick) Neil Vincent (North Huron) Warden Paul Gowing
Clerks and Treasurers Association	Nancy Michie (Morris-Turnberry) Brad Knight (Huron East)
Local Municipal Councillors	Linda Henhoffer (Howick) Jim Nelemans (Morris-Turnberry)
Ausable Bayfield Conservation Authority	Geoff Cade
Maitland Valley Conservation Authority	Deb Shewfelt
Ministry of the Environment	Ted Briggs
Ministry of Agriculture and Food	Jacquie Empson-Laporte
Agricultural Representatives	Jack Kroes (CFFO) Joe Vermunt (HSCIA) Stefan Zehetner (HSCIA) Paul Klopp (HFA)
Huron Manufacturing Association	Jeff Hearn
Huron Tourism Association	Rosemary Davis
Cottage Associations	Roger Watt (Ashfield Colborne Lakefront Assoc.) Jan Purvis (Bluewater Shoreline Residents Assoc.)
Planning Department	Scott Tousaw Susanna Reid Dave Pullen
Health Unit	Jean-Guy Albert
Ontario Pork Producers	Sam Bradshaw
Huron Federation of Agriculture	Margaret Vincent
Source Protection	Jenna Allain
Lake Huron Centre for Coastal Conservation	Pam Scharfe
Huron Stewardship Council	Rachel White

EXTREME LAKE LEVELS SUBCOMMITTEE MEMBERS		
Name	**Organization**	**Email**
Alec Scott	Ausable Bayfield Conservation Authority, Water and Planning Manager	ascott@abce.on.ca
Deb Shewfelt	Maitland Valley Conservation Authority	delbert.shewfelt@gmail.com
Erinn Lawrie	Lake Huron Centre for Coastal Conservation	erinn.lawrie@lakehuron.on.ca
Geoff Cade	Ausable Bayfield Conservation Authority, Supervisor of Water and Planning	gcade@abca.on.ca
Geoff Peach	Lake Huron Centre for Coastal Conservation, Project Director	geoff.peach@lakehuron.on.ca
Jan Purvis	Bluewater Shoreline Residents Association	jpurvis@rogers.com
Jim Ginn	County Councillor and Mayor, Central Huron	jginn@centralhuron.com
Myles Murdock	Town of Goderich	mylesmurdock@hurontel.on.ca
Pam Scharfe	Lake Huron Centre for Coastal Conservation	pamela.scharfe@lakehuron.on.ca
Roger Watt	Ashfield Colborne Lakefront Association	rwwatt@uwaterloo.ca
Rosemary Davis	Huron Tourism Association	rdavis@hogerry83.ca
Rowland Howe	Goderich Port Management Corporation	
Steve Jackson	Maitland Valley Conservation Authority, Flood and Erosion Safety Services Coordinator	sjackson@mvca.on.ca
Sue Haskett	Bluewater Shoreline Residents Associations	sue@haskettfh.com
Susanna Reid	Planning & Development Dept, Planner	sreid@huroncounty.ca

Appendix 10: List of presentations

November 27, 2015: Huron County Lake Levels Integrated Assessment - Presentation to Water Protection Steering Committee, Holmesville, Huron County. By Lynne Peterson

January 15, 2016 workshop presentations:

Federal legislation and programs – Agnes Richards, Environment Canada

Provincial and municipal land-use planning policies and processes – Susanna Reid, Planner, Huron County

Conservation Authority legislation, regulations and policy role; Shoreline Management Planning - Alec Scott, Ausable Bayfield Conservation Authority (ABCA)

Bluff Erosion – public safety, emergency planning – Steve Jackson, Maitland Valley Conservation Authority (MVCA)

Bluff Erosion – case studies – Tanya Wanio

Lake levels impact on commercial shipping – Meghan Allerton, University of Toronto Ecological Modelling Lab

Harbours and Tourism – economic impacts of low water levels – Helen MacRae

Summer consultation presentation

May 14 - Ashfield-Colborne Lakefront Association

May 27 – "Is the Coast Clear" conference

June 4 – Bluewater Shoreline Residents Association

May 17 – Presentation for Graham Sustainability Institute project meeting, Ann Arbor, Michigan