APPENDICES:

Appendix A: ABCA SMP Update Steering Committee Terms of Reference

Steering Committee - Terms of Reference

Dated: August 6, 2015

Updated: 1 Revision

Contents

Approval Statement

The attached Terms of Reference describe the role and mandate of the Shoreline Management Plan Steering Committee. These Terms of Reference describe the role, mandate and responsibilities of the Steering Committee with respect to the update of the Ausable Bayfield Conservation Authority Shoreline Management Plan.

______________________________________ ________________________________

Alec M. Scott, Project Manager Date
Ausable Bayfield Conservation Authority

1.0 Purpose & Background:

The Ausable Bayfield Conservation Authority (ABCA) has a long history of commitment to effective shoreline management that can be traced back to 1994 when the agency developed the first Shoreline Management Plan. Since that time, ABCA has updated the Shoreline Management Plan to reflect the new Provincial Policy Statement and new policies contained therein relating to Natural Hazards. There have been many changes affecting the implementation of the Shoreline Management Plan since adoption of the 2000 update, including the release of an updated Provincial Policy Statement, new and more refined photography and mapping as well as the emergence of new and some might say, increasingly challenges issues affecting the shoreline. The Shoreline Management Plan provides the platform for the delivery of ABCA's shoreline Regulations and Planning programs. Keeping the Plan updated is critical for the Authority and in recognition of this, the Ausable Bayfield Conservation Authority is updating its Shoreline Management Plan.

Given the complexities associated with shoreline management, the diversity of issues and concerns and the range of individuals and organizations with an interest in the outcome, ABCA recognizes that the successful development and implementation of an updated Shoreline Management Plan will require collaboration by government, industry and community groups. The Ausable Bayfield Conservation Authority has created a Steering Committee to oversee the development of the updated Shoreline Management Plan. These Terms of Reference articulate the role, responsibilities and mandate of the Steering Committee in more detail.

The Steering Committee will assist the ABCA by working with staff and members of the Consulting Team who have been retained to update the Shoreline Management Plan. All Steering Committee members will have an equal voice at the Committee table, recognizes that the updated Shoreline Management Plan will be approved by the ABCA Board of Directors, and implemented by ABCA staff in collaboration with its partners. The objective of this exercise is to work on the basis of a consensus model of decision making, recognizing that where there are differences of opinion regarding project focus and orientation, we will respect the views of all who participate. Final decision making authority rests with ABCA.

2.0 Mandate

To work collaboratively with the Ausable Bayfield Conservation Authority and members of the Consulting team to champion the development of an updated Shoreline Management Plan. To be responsible for providing project direction and guidance and to oversee project accountability.

Membership:

A Steering Committee has been formed to provide advice and guidance with respect to the Shoreline Management Plan update. The Steering Committee consists of a broad spectrum of ABCA partners from government, industry and community. Confirmed representatives on the Steering Committee include:

- Ausable Bayfield Conservation Authority (Alec Scott, Geoff Cade)
- County of Huron (Monica Walker-Bolton)
- County of Lambton (Patti Richardson)
- Bluewater Shoreline Residents Association

- The Municipality of Lambton Shores (TBD)
- The Municipality of South Huron (Marissa Vaughan)
- The Municipality of Bluewater (John Gillespie)
- The Municipality of Central Huron (Burkhard Metzger)
- Ministry of Natural Resources and Forestry (Al Murray; alternate Rose Whalen)
- St. Clair Conservation Authority (Patty Hayman)
- Maitland Valley Conservation Authority (Steve Jackson)
- Huron District Contracting (Jim Peever)

Additional members may be added to the Steering Committee as deemed advisable and appropriate by the Steering Committee to ensure that a diversity and range of perspectives are brought forward.

3.0 Role & Responsibilities:

The following roles and responsibilities have been defined for the Steering Committee Members:

- To promote collaboration among the members of the Steering Committee and the broader Project Team (ABCA Staff & the Consulting team).
- To understand the delegated responsibilities assigned to the ABCA under the Conservation Authorities Act and the Planning Act for both permitting and planning.
- To contribute to the exchange of information and ideas at the Project Team meetings.
- To represent their respective constituencies with an interest in shoreline management.
- To support the shoreline management planning process and provide advice and input relative to shoreline management issues.
- To raise awareness and understanding of the importance of the updated Shoreline Management Plan, and to this end, act as champions of the process.
- To review information provided by the Consulting Team and ABCA staff.
- To provide advice and guidance to the ABCA and the Consulting Team particularly as it relates to community engagement and process.
- To review the Shoreline Vision Statement as articulated in the 2000 Edition of the ABCA Shoreline Management Plan to determine if it remains relevant or requires revision and enhancement.
- To consider the viewpoints and issues raised by other members of the Steering Committee and to offer advice and guidance to ABCA staff and the consulting team regarding the options to address viewpoints and issues.
- To meet as required over the course of the project and to provide guidance regarding a project meeting schedule.
- To review any draft documents associated with the updated Shoreline Management Plan.

4.0 Tasks:

1. To provide input to the shoreline management planning process and to offer recommendations for community engagement (logistics, key messages, timing).
2. To act as project ambassadors to ‘spread the word’ about the updated Shoreline Management Plan among their constituency members.
3. To provide input to the shoreline management plan.
4. To review the existing 2000 edition of the Shoreline Management Plan.

5. To work with the other Steering Committee members to collectively develop a shared vision and potentially a set of shared policy objectives/governing principles.
6. To make recommendations to ABCA that encourage the development of policies and approaches that are reasonable, practical, implementable and supported by solid science and which reflect the ABCA's delegated responsibilities under the Conservation Authorities Act and the Planning Act.

5.0 Meeting Procedures:

The Steering Committee will meet regularly to review progress to ensure the updated Shoreline Management Plan develops in a coordinated and comprehensive manner.

The Steering Committee will be led by Alec Scott, and assisted by Karen Wianecki and Judy Sullivan, as members of the Consulting Team.

The meetings of the Steering Committee will be considered open meetings. Interested members of the public are welcome to attend. Fifteen (15) minutes will be set aside just before the end of each Steering Committee meeting to accommodate questions, comments and deputations from interested members of the public.

The Consulting Team will provide scientific support to the Steering Committee.

Members are expected to personally attend the meetings and fully participate in the discussion.

Minutes that highlight decisions and actions will be completed at the end of each meeting and circulated in a timely manner to Committee members.

Decisions will be made by consensus. If consensus cannot be reached, a minority opinion will be documented.

6.0 Timeframe:

The work of the Steering Committee will be completed when the updated Shoreline Management Plan has been developed. The expected date of completion is October 2016.

Steering Committee - Suggested Milestone Dates

Meeting No.	Steering Committee Meeting Date	Potential Agenda Topic
1	July	Inaugural Meeting to Review the Process & The Project Outcomes (Organized by ABCA) – has already taken place
2	TBD	Meeting Date with consulting team represented • Review & Endorsement of Terms of Reference • Outline of Project Work Plan & Process • Confirmation of Steering Committee Meeting Schedule
2	TBD – October/Nov.	Steering Committee Think Tank • Results of Background Review The Vision & Guiding Principles • Issues & Opportunities • Who Needs to be Engaged • Considerations for Successful Engagement
3	Spring 2016	Early Findings & Results of Technical Assessment & Analysis • Shoreline Process • Bluff Erosion • Shoreline Protection Works • Updated Long Term Erosion Rate • Harbour Dredging & Potential Impacts – Findings & Recommendations • Policy impacts
4	Summer – Early Fall 2016	Draft SMP

Appendix B: Community Engagement Strategy, News Release & Newsletters

Community Engagement Strategy

The Shoreline Management Plan was developed with input from the broader community. This engagement took place in a number of ways:

1. Steering Committee representatives were selected from a diverse group of stakeholders, including community members.
2. All Steering Committee meetings were deemed to be 'open public meetings'.
3. Every Steering Committee meeting included time on the Agenda for deputations from community members.
4. The Shoreline Management Plan commenced with a Community Survey to engage interested community members in the process. The input secured from the community survey provided important insight regarding the structure of the SMP Update and also the issues that were top of mind for community members.
5. Regular process updates were provided to interested community members in the form of News Releases and Community Newsletters.
6. The Steering Committee demonstrated a strong desire to ensure that there was ample opportunity for community input and engagement throughout the process, including the decision to post the draft Consultant Report on the website for a sufficient period of time to secure feedback before proceeding.

News Release
Ausable Bayfield Conservation Authority

FOR IMMEDIATE RELEASE **DATE OF ISSUE:** October 21, 2015

Shoreline Management Plan Steering Committee invites public to complete electronic survey about issues facing shoreline

Ausable Bayfield Conservation Authority (ABCA) is updating Shoreline Management Plan; Local stakeholders are taking part on Steering Committee; survey is now online

Ausable Bayfield Conservation Authority (ABCA) last completed a Shoreline Management Plan in 2000. A Steering Committee and consulting team are now conducting work to update the plan. The updated Shoreline Management Plan should be completed by the end of 2016.

The Steering Committee includes local people with an interest in shoreline issues, representing seasonal and shoreline residents, industry, neighbouring conservation authorities, the counties of Lambton and Huron, and representatives of the four shoreline municipalities in Ausable Bayfield watersheds. The Steering Committee is providing individuals in Ausable Bayfield watersheds with a chance to provide early input through an online survey. The survey has 18 questions so property owners can offer some of their concerns, issues, and priorities as the Steering Committee moves forward with its work.

The conservation authority is to send correspondence to a number of people with an interest in shoreline management to invite them to complete the survey. The survey is also available online. You may complete the survey directly by visiting this link: www.surveymonkey.com/r/Shoreline-Management-Plan-Update. The survey is to be open until February 1, 2016. Survey respondents may provide their name and contact information to be entered into draws to possibly win one of three grand prizes to be awarded of a family pass for the year to Rock Glen Conservation Area in Arkona. Each Family Season's Pass prize is valued at $45. Public opportunities for input, in addition to the survey, are to include public open houses planned for 2016 when some of the technical work is to be ready in draft.

The ABCA Shoreline Management Plan was completed in 1994 and updated in 2000, said Alec Scott, Water and Planning Manager with ABCA. "It is important to regularly review these documents, as lake levels fluctuate with weather and climate changes," he said. It is important to ensure the Shoreline Management Plan captures the priorities of the people along the shoreline and in our inland communities, according to Scott. "We need to ensure the science is current, that we share knowledge and ideas with municipalities and people in the watershed community, and ensure that strategies are reasonable and effective to manage a number of shoreline issues," he said.

A key component of the Shoreline Management Plan addresses the shoreline hazard limits for flooding, erosion, and dynamic beaches. The document is used both for reference and to direct changes to land use planning documents of lakeshore municipalities.

Some of the main objectives of a Shoreline Management Plan include:

- Reducing or eliminating damage due to periods of erosion, flooding and dynamic beach movement that may occur to development close to the shore of a Great Lake or large inland lake.
- Directing new development away from hazardous areas.
- Helping to protect existing development from potential impacts of new development.

People may find out about the Plan update by visiting the shoreline management plan web page at www.abca.on.ca/page.php?page=shoreline-management. The page includes answers to a list of frequently asked questions (FAQs). It also includes the link to the survey.

Anyone with further questions is also invited to contact Alec Scott or Geoff Cade at Ausable Bayfield Conservation at 519-235-2610 or toll-free 1-888-286-2610 or email info@abca.on.ca.

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CONTACT: Geoffrey Cade, Water and Planning Supervisor, at Ausable Bayfield Conservation Authority (ABCA), 519-235-2610 or 1-888-286-2610 or e-mail gcade@abca.on.ca

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News Release
Ausable Bayfield Conservation Authority (ABCA)

FOR IMMEDIATE RELEASE **DATE OF ISSUE:** August 12, 2016

Draft Updated Shoreline Management Plan to be posted online

Consulting team presents Draft Updated Shoreline Management Plan recommendation report to Steering Committee; Committee asks that document be posted online for review, public comments

The consulting team for the Ausable Bayfield Conservation Authority (ABCA) Shoreline Management Plan Update provided its Draft Updated Shoreline Management Plan recommendation report to the Steering Committee at a meeting in the Masonic Hall, Exeter on Tuesday, July 26, 2016.

The ABCA had originally planned to complete updates to the SMP before the end of 2016. Completion of an Updated Shoreline Management Plan and local implementation policies is now not expected until later in 2017. Public events originally proposed for 2016 are not taking place until 2017.

The Steering Committee includes representation from diverse shoreline and industry interests. Discussion at the July Steering Committee meeting underlined the need to allow sufficient time for public access, comment, and to address the comments on the new Draft Updated Shoreline Management Plan (consultants' recommendation report). The document is based on current scientific knowledge and provincial policies and was prepared by the consulting team. The consulting team was led by Karen Wianecki, of Planning Solutions Inc., Judy Sullivan, of Aqua Solutions 5 Inc., and Robin Davidson-Arnott, University of Guelph. Additional input was provided by Billy Singh, of Terraprobe, and Ryan Mulligan, of Queen's University. Some of the team members presented the rationale for their recommendations through presentations to the Steering Committee at the July 26 meeting.

The Steering Committee decided the draft plan should be posted online for public review and comments. After comments on the document are received, reviewed, and considered by Ausable Bayfield Conservation Authority and the Steering Committee, the ABCA will work with municipalities and other reviewing bodies in 2017 to develop local policies through a draft implementation plan.

Staff members of ABCA are to add maps and appendices to the Draft Updated Shoreline Management Plan (consultants' recommendation report) and are to post it for public review by September 1, 2016. There will then be a 90-day period for written comments, on this posting, by the public. A printed copy of the document will also be available for the public to review, at local libraries and the ABCA office, at 71108 Morrison Line, east of Exeter, for people who do not have convenient access to the Internet.

The document is to be posted on the Shoreline Management Plan (SMP) web page at abca.on.ca. Once the draft is posted, shoreline property owners and other interested people are invited to review the document, download it for free, and provide written comments to ABCA. To reach the web page, click on the Shoreline Management icon on the abca.on.ca home page or use the search tool on the home page. You may also go directly to the page at this link: http://www.abca.on.ca/page.php?page=shoreline-management. Staff members are to send an update email, once the document is posted, to all subscribers of the Shoreline Management Plan newsletter. To subscribe to this free electronic newsletter visit this link: http://eepurl.com/bxn8_5.

In addition to the Recommendation Report to be posted in the coming weeks, Ausable Bayfield Conservation has posted online a new discussion paper on processes controlling erosion and recession of cohesive shorelines. The new document is called *Erosion of Cohesive Bluff Shorelines*. That discussion paper focuses on the Ausable Bayfield shoreline north of Grand Bend. You are invited to download this document for free at abca.on.ca. Robin Davidson-Arnott, Professor Emeritus, University of Guelph, wrote the paper. The term cohesive shoreline is used to describe coasts developed in relatively weak sediments which include some silt and clay (to provide the cohesion). Coastal erosion results in the development of cliffs which are called cohesive bluffs to distinguish them from the traditional cliffs formed in hard bedrock.

The ABCA has also posted another recent discussion paper that focuses on the potential impacts of climate change on coastal processes across the ABCA watershed area. That paper is called *Climate Change Impacts on the Great Lakes – A discussion paper on the potential implications for coastal processes affecting the SE shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority*. This document is also posted for free download on the Shoreline Management Plan page.

Several people were in the public gallery for the July 26 meeting. A delegation from the shoreline area of Melena Heights, north of Bayfield, presented at the Steering Committee about concerns related to the impact drainage changes may be adding to shoreline erosion in the area. The delegation stressed that while the timeline for the Shoreline Management Plan Update may now stretch into 2017, discussion of potential responses to their concerns needs to happen soon. ABCA staff agreed to meet with the residents' representative for more detail about the concerns after the Steering Committee meeting.

The 90-day period for public comment on the Draft Updated Shoreline Management Plan (consultants' recommendation report) takes place between September 1, 2016 and December 1, 2016. Written comments on the document, or questions, may be sent to Alec Scott or Geoff Cade through the staff contacts page at abca.on.ca. You are also invited to phone 519-235-2610 or toll-free 1-888-286-2610.

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MEDIA CONTACT:

Geoffrey Cade, Water and Planning Supervisor, at Ausable Bayfield Conservation Authority (ABCA), 519-235-2610 or 1-888-286-2610 or e-mail gcade@abca.on.ca

News Release
Ausable Bayfield Conservation Authority

FOR IMMEDIATE RELEASE **DATE OF ISSUE:** November 5, 2015

Local people showing their interest in shoreline issues by their participation in survey, Steering Committee

Public open houses about Shoreline Management Plan Update project to take place in summer of 2016 so shoreline and seasonal residents in Ausable Bayfield watersheds are able to attend and review technical work that is being prepared over coming months; Other public involvement includes first electronic survey (open for public responses between 2015 and February 1, 2016), stakeholder participation on Steering Committee; Public also subscribing to free electronic newsletter

Shoreline residents and other interested people are showing an interest in shoreline management issues by taking part in an electronic survey and subscribing to a newsletter about the Ausable Bayfield Conservation Authority (ABCA) Shoreline Management Plan Update.

Staff of the ABCA say they are at the start of a Plan Update process that will take more than a year to complete. No drafts or recommendations have been prepared yet and technical work will not be ready for public comment until 2016, said Alec Scott, Water and Planning Manager with ABCA. He said public open houses have not taken place yet and are to be held in the summer of 2016 so all residents, including seasonal residents, are able to attend. Staff members expect technical work to be ready by summer of next year so the public will have the latest mapping and shoreline information to review at that time.

An electronic survey is one of the first opportunities available for people to provide input about shoreline issues of concern to them. Local people have already started to respond to the survey and to subscribe to a free electronic newsletter with updates about the project. "We are very pleased with the high level of public interest that has been shown already," said Scott. He said the Steering Committee and the ABCA are in the very early stages of updating technical work about the shoreline and identifying shoreline issues as provided by the public. "We want all seasonal residents, shoreline residents, and other interested people to have the opportunity to attend open houses so that's why the Steering Committee has decided to hold those public meetings next summer," he said. "We also want to make sure we will have updated information ready about the issues and the state of the shoreline so local residents have current and meaningful information to review as they provide comments."

The online survey is available at this link: www.surveymonkey.com/r/Shoreline-Management-Plan-Update. The survey is to be open until February 1, 2016. This is one of the first of many opportunities for the public to be involved over the coming year.

The conservation authority is also releasing the first of several free electronic newsletters about the Plan Update to keep people informed about opportunities to be involved over the coming year. The newsletter is to be available on the shoreline management web page. You may subscribe to the newsletter at this link: http://eepurl.com/bxn8_5

People may find out about the Plan update by visiting the shoreline management plan web page at www.abca.on.ca/page.php?page=shoreline-management. The page includes answers to a list of frequently asked questions (FAQs). It also includes the link to the survey.

The first ABCA Shoreline Management Plan was completed in 1994 and it was last updated in 2000. The updated Shoreline Management Plan should be completed by late 2016. A local Steering Committee and consulting team are now working with the conservation authority and area stakeholders to guide the update over the next year. The Steering Committee includes local people with an interest in shoreline issues, representing seasonal and shoreline residents, industry, neighbouring conservation authorities, the counties of Lambton and Huron, and representatives of the four shoreline municipalities in Ausable Bayfield watersheds. All meetings of the Steering Committee are open to the public and anyone with an interest is invited to attend. Fifteen (15) minutes are to be set aside at the end of each Steering Committee meeting to allow members of the public to ask questions, make comments, or present delegations to the Steering Committee. If you wish to make a presentation to the Steering Committee, please contact ABCA staff in advance.

Anyone with further questions about the Plan Update is also invited to contact Alec Scott or Geoff Cade at Ausable Bayfield Conservation at 519-235-2610 or toll-free 1-888-286-2610 or email info@abca.on.ca

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CONTACT: Geoffrey Cade, Water and Planning Supervisor, at Ausable Bayfield Conservation Authority (ABCA), 519-235-2610 or 1-888-286-2610 or e-mail gcade@abca.on.ca

News release – Shoreline Management Plan – Public getting involved – issued November 5, 2015

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News Release
Ausable Bayfield Conservation Authority

FOR IMMEDIATE RELEASE **DATE OF ISSUE:** April 28, 2016

Higher lake levels, shoreline erosion, weather events make it important for property owners to be aware of hazards, risks

Lake Huron water levels at highest in years; higher water combined with wet ground, natural hazards, pose risks of more gully and bluff erosion; potential slope failure

Lake levels are the highest they have been in years. These higher-than-average lake levels, combined with large amounts of rain, high winds and wave action due to sparse ice cover has led to erosion at the base of the bluffs and an increase in gully erosion in some areas. This in turn leads to higher risk of slope failures along the lakeshore.

Water levels in Lake Huron are above the long-term average and higher than this time last year. Lake water levels are, in fact, higher than they have been since 1998 and they have rebounded from the period of lower-than-average levels that took place between late 1999 and early 2014. "Property owners should be aware of shoreline risks and natural hazards and remain diligent in monitoring their property for any sign of potential slope failure or bluff collapse," said Alec Scott, Water and Planning Manager with Ausable Bayfield Conservation Authority (ABCA). "Unfortunately, it is very difficult to predict when bluff failures will happen and how big those failures will be." It is important for property owners to regularly check the condition of their bluff and property and if they have any concerns, to seek advice from appropriately qualified engineering and technical professionals. In the event of a significant bluff or slope failure that impacts residential structures, property owners should notify their municipality and the ABCA immediately.

Factors affecting bluff erosion include wave action, lake levels, groundwater flow and saturation, wind, freeze-thaw cycles, bluff height, soil type, and the angle of the bluff. Heavy rainfall in early 2016, combined with a number of freeze-thaw cycles this past winter, increases the potential for erosion along the Lake Huron shoreline. Saturated clay-till bluffs, combined with erosion from wind, storm events, and higher lake levels, can lead to increased slope instability along the shoreline and increased erosion of gullies.

Environment and Climate Change Canada records indicate that March precipitation across the entire Lake Huron basin (Lake Huron, Lake Michigan and Georgian Bay) was almost double the long-term average for the month of March. In Ausable Bayfield watersheds, the precipitation was even higher. Based on three indicator stations, which are part of the ABCA precipitation monitoring network, average rainfall for March was close to three times the normal amount.

In an average year, lake levels in Lake Huron would typically rise approximately four (4) centimetres (cm) in February and March, according to Frank Seglenieks, Water Resources Engineer with Environment and Climate Change Canada. In February and March of 2016, lake levels rose about 14 cm. This increase represents the fourth largest rise at that time of the year since the start of water level tracking in 1918, according to Seglenieks. Lake Huron water levels in March of this year were 13 centimetres above the same period the year before and 32 cm above the long-term average for March. (This year's March level is still 51 cm below the record March level set in 1986).

The lake level in Lake Superior, which contributes a significant proportion of water supplies to Lake Huron is also well above average and will continue to contribute to the high levels experienced in Lake Huron for at least the rest of this year. As a consequence, it is predicted that water levels in Lake Huron will remain above average this year even if weather conditions are fairly dry.

There are inherent natural hazards and risks along any shoreline. Higher water levels and wet weather add to that risk, according to the ABCA. Bluff erosion is a natural process that has been occurring along the Great Lakes shorelines since they were formed more than 10,000 years ago. This erosion process is necessary to the ecology of the shorelines as sand beaches would disappear without some erosion. However, with higher lake levels and more rain events early this year, the erosion process is now much more visible. Property owners need to be aware of the increased erosion and slope failure potential and watch for any sign of slope failure on their property. ABCA encourages property owners to contact the conservation authority with any questions.

The ABCA is currently updating its Shoreline Management Plan and is working with a Steering Committee and consulting team to complete this work. Information about the Shoreline Management Plan may be obtained from the ABCA's website at: http://www.abca.on.ca/page.php?page=shoreline-management

The conservation authority is adding new information materials on this web page in the coming weeks.

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CONTACT: Alec Scott, Water and Planning Manager, at Ausable Bayfield Conservation Authority (ABCA), 519-235-2610 or 1-888-286-2610 or e-mail ascott@abca.on.ca

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AUSABLE BAYFIELD CONSERVATION
CREATING AWARENESS | TAKING ACTION

Newsletter

Shoreline Management Plan Update

November 2015 • Number 1

Shoreline Management Plan to be updated

Ausable Bayfield Conservation Authority (ABCA) is updating the Shoreline Management Plan (SMP). The last Shoreline Management Plan was completed in 2000. The updated Shoreline Management Plan is expected to be completed by the end of 2016.

A Steering Committee is working with a consulting team and the conservation authority to guide the Shoreline Management Plan update over the next year. Local shoreline residents, industry representatives, and other stakeholders sit on the Steering Committee.

The Steering Committee is made up of representatives from:

- ✓ Shoreline residents and cottage associations
- ✓ Industry
- ✓ Each of the four shoreline municipalities within the ABCA jurisdiction
- ✓ Counties of Huron and Lambton
- ✓ Ontario Ministry of Natural Resources and Forestry
- ✓ Two adjacent conservation authorities

What is a Shoreline Management Plan?

The objectives of a Shoreline Management Plan (SMP) are to develop and support solutions to current and future issues and problems along the shoreline. The primary focus of the Ausable Bayfield Conservation Authority Shoreline Management Plan is to address the shoreline hazards for flooding, erosion, and dynamic beaches and their impact on shoreline development.

For more information, we have compiled answers to some frequently asked questions:

Frequently Asked Questions

We have developed a Frequently Asked Questions (FAQ) backgrounder that provides more information about the Shoreline Management Plan process and details. This may be found online at www.abca.on.ca for easy access and download. Simply visit the Shoreline Management Plan web page at: http://www.abca.on.ca/page.php?page=shoreline-management or click on the Shoreline Management Plan image on the home page.

Your ideas matter. We look forward to hearing from you.

You and Your Shoreline – Survey

We have developed a Community Survey which we would like to invite you to complete. The survey can be easily accessed through the following link:

http://surveymonkey.com/r/Shoreline-Management-Plan-Update

This is one of the first of many opportunities to provide input over the next year. The survey is open until February 1, 2016.

Newsletter Updates

If you are interested in receiving regular information about the Shoreline Management Plan Update, you are welcome to subscribe to our electronic newsletter at the following link: http://eepurl.com/bxn8_5

Copies of our newsletter are also available on the Shoreline Management Plan web page.

Public Open Houses and Meetings

We will be hosting public open houses in the summer of 2016, once we have updated technical information to share with you. Notices of these open houses will be posted, well in advance, on the website at **abca.on.ca**. We are focusing on the summer of 2016 to ensure that those who enjoy Lake Huron as seasonal and cottage residents will be able to participate.

All meetings of the Steering Committee are open to the public and we invite anyone with an interest to attend. Fifteen (15) minutes will be set aside at the end of each Steering Committee meeting to allow members of the public to ask questions, make comments, or present delegations to the Steering Committee. If you wish to make a presentation to the Steering Committee, please contact ABCA staff in advance.

The updated Shoreline Management Plan, when finished late in 2016, will be used as a reference document by ABCA staff and by shoreline municipalities in the ABCA watershed.

Members of our consulting team are completing a review of the existing mapping and aerial photography to provide updated information on long-term erosion rates along the shoreline.

We will be working to develop a new Updated Shoreline Management Plan over 2015 and 2016.

Alec Scott, Water and Planning Manager with ABCA, is the Project Lead.

The Shoreline Management Plan is being updated to ensure that the Plan reflects current mapping, legislation, policies, guidelines and technical information related to shoreline hazards and current land use trends along the Lake Huron shoreline that is within ABCA jurisdiction.

The updated Shoreline Management Plan will update the hazard limits for flooding, erosion and dynamic beaches to reflect current mapping standards identified in the *Conservation Authorities Act*, associated Ontario Regulations and the 2014 Provincial Policy Statement as well as new policies and guidelines that have been developed since the Plan was last updated.

We are committed to developing a process that allows anyone with an interest to share their ideas and to receive regular updates on our progress.

Contact us

Still have more questions about the work to update the Shoreline Management Plan? Please call Alec Scott or Geoff Cade at **519-235-2610** or toll-free at **1-888-286-2610**. You are also welcome to send us an email through our staff contact page at:

http://www.abca.on.ca/contact_staff.php

We look forward to developing the new Shoreline Management Plan with you.

AUSABLE BAYFIELD CONSERVATION
CREATING AWARENESS | TAKING ACTION

Shoreline Management Plan (SMP) Newsletter

Ausable Bayfield Conservation Authority (ABCA)

Newsletter Number Two • May 2016

Shoreline Management Plan (SMP) Update

Reporting on Progress

A Little Background to Begin …

Ausable Bayfield Conservation Authority (ABCA) is updating the Shoreline Management Plan. The previous Shoreline Management Plan (SMP) was completed in 2000. The updated Shoreline Management Plan is expected to be completed by the end of 2016.

The Shoreline Management Plan is being updated to ensure it reflects current mapping, legislation, policies, guidelines and technical information related to shoreline hazards and current land use trends along the Lake Huron shoreline, within the jurisdiction of the ABCA.

The updated Shoreline Management Plan will, as necessary, update the hazard limits for flooding, erosion, and dynamic beaches to reflect current mapping standards identified in the *Conservation Authorities Act*, associated Ontario Regulations, and the 2014 *Provincial Policy Statement* as well as new policies and guidelines that have been developed since the Plan was last updated.

The updated Shoreline Management Plan will be used as a reference document by ABCA staff and by shoreline municipalities in the ABCA watershed.

Steering Committee Guiding Development of Shoreline Management Plan Update

The Shoreline Management Plan update is being guided by a local Steering Committee. The Steering Committee includes local people with an interest in shoreline issues, representing seasonal and shoreline residents, industry, neighbouring conservation authorities, the counties of Lambton and Huron, and representatives of the four shoreline municipalities in Ausable Bayfield watersheds.

All meetings of the Steering Committee are open to the public – anyone interested in attending is welcome to attend and fifteen minutes are set aside at the end of each Steering Committee meeting to allow members of the public to ask questions, make comments, or present delegations. Please contact Alec Scott or Geoff Cade at 519-235-2610 or toll-free at 1-888-286-2610 if you would like to make a presentation.

If you are planning to attend, please call ahead so the committee can ensure there is enough space for seating. Delegations should also call in advance to ensure there is time for their delegation to be heard.

> **The next Steering Committee meeting is to be held on Thursday, May 12, 2016 in the Ausable Bayfield Conservation Authority (ABCA) boardroom, at 71108 Morrison Line, 2 km east of Exeter, starting at 9:30 a.m.**

Reporting On Our Progress ...The Survey

We heard from 68 individuals who took the time to complete the web survey. More than 90 per cent of those who responded live in the shoreline study area in the Ausable Bayfield watershed and most are property owners and/or ratepayer group members. Thank you for having taken the time to provide comments on the issues of concern to you. These comments are valuable in informing the work of the Steering Committee and project team and they will help improve the final document.

What Did You Tell Us?

You told us that you are most concerned with:

- **Water quality**
- **Bluff and beach erosion**

You also told us that environmental degradation is an issue you are concerned about.

There are many areas, from Grand Bend to St. Joseph, the Old Ausable Channel, Oakwood Park, Turnbull's Grove, Norman Heights Beach, Bayfield, and the Dunes north of Grand Bend, to name a few, that are of geographic interest and concern to you.

While some of you did not support the existing Shoreline Management Plan, others strongly support the plan.

You told us that there needs to be a science-based application of hazard setbacks and that it will be important for the new Shoreline Management Plan to protect the integrity of coastal processes.

Recession Rate Calculations

Since October, members of our consulting team have been working to review shoreline data and complete a comprehensive erosion rate analysis for the study area shoreline.

A detailed and in-depth calculation of an updated assessment of rates of erosion (recession) provides the basis for estimating future erosion rates.

These rates will be used to help establish distances that development will need to be away from the lake and its bluff.

Once the final recession rate calculations are complete, information will be shared with the community through the draft Shoreline Management Plan Update.

Look for a draft to be posted on the ABCA website at abca.on.ca in July of 2016.

Climate Change Impacts

It is vital for the development of any management strategies, including an updated ABCA Shoreline Management Plan, to consider the potential effects of changes to our weather and climate locally and globally. Since October, members of the consulting team have been assessing the potential impacts of climate change and have developed an initial Discussion Paper highlighting some of the anticipated effects. Results of this work have allowed us to reach the following conclusions:

- Average annual temperatures in the region will likely increase 2-7°C as a result of larger increases in winter temperatures and a smaller increase in summer temperatures. This will, in turn, impact lake temperatures, lake-effect snowfall, winter ice cover, and fish habitats. It will also likely affect the length of the recreational season.
- Precipitation is predicted to remain the same or increase by up to 20 per cent, mostly in the northern half of the basin. More precipitation will fall as rain rather than snow and there may be frequent heavy downpours. The number of intense storms may increase.
- There is however a greater degree of uncertainty for precipitation and evapotranspiration than for temperature. As a result, it is difficult to predict what will happen to mean lake levels.
- The duration and extent of ice cover in southern Lake Huron has already decreased and is expected to decrease further by the end of the century.
- The most important impact of this longer ice-free season on coastal processes will be an increase in the number of storms associated with large waves and large storm surges.

2 of 3

The increase in the number of storms is expected to drive larger volumes of longshore sediment transport and an increase in the rate of down-cutting of the nearshore and erosion of the bluff toe along cohesive shorelines.

Want to learn more about the potential effects of climate change? Download a copy of the Discussion Paper here:

NEW – A new discussion paper is available for free download. This document identifies the potential impacts of climate change on coastal processes across the Ausable Bayfield Conservation Authority (ABCA) watershed. This document has been prepared by Dr. Robin Davidson-Arnott (Draft – Version March 31, 2016).

Download *Climate Change Impacts on the Great Lakes – A discussion paper on the potential implications for coastal processes affecting the SW shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority* at this link:

http://abca.on.ca/downloadfile.php?Item=483

Slope Stability

All property owners along the Lake Huron shoreline need to be aware of the potential hazards that exist. Ausable Bayfield Conservation Authority has recently issued a news release to provide important information to shoreline property owners about the need to be constantly monitoring the condition of their shoreline property for any signs of slope failure.

For more information on the increased potential for bluff and slope failure click on the Ausable Bayfield Conservation website at this news link:

http://www.abca.on.ca/news_item.php?ItemID=644

ABCA has an ongoing mandate to protect life and property through its planning and regulations programs. With respect to the new Shoreline Management Plan, more information will be posted on the website at **abca.on.ca**. Stay tuned.

Shoreline Protection:

The SMP update will consider the issue of shoreline protection and offer policy recommendations regarding shoreline protection structures and lake bank stabilization measures.

The draft will be shared with members of the community and an opportunity provided to offer input and suggestions.

Want to Stay Informed?

If you are interested in receiving regular updates, we invite you to subscribe to our free electronic newsletter at the following link:

http://eepurl.com/bxn8_5

A copy of the first newsletter issue is at this link:

http://ow.ly/UlCJZ

Community Meetings to Be Held in August 2016

We will be hosting public open houses in the summer of 2016, once we have updated technical information to share with you. Notices of these community meetings will be posted on the website at **abca.on.ca**. A news release about the events will also be circulated in advance to local media and on social media. We are focusing on the summer of 2016 to ensure that those who enjoy Lake Huron as seasonal residents and cottagers will be able to participate. If you are not able to attend the meetings – but want to find out more and provide input – please contact the ABCA for more ways to provide your comments.

???

Still Have More Questions?

Still have more questions about the work ABCA will be doing to update the Shoreline Management Plan? Please call Alec Scott or Geoff Cade at 519-235-2610 or toll free at 1-888-286-2610. You are also welcome to send them an email through the staff contact page at:

http://www.abca.on.ca/contact_staff.php

3 of 3

You are receiving this newsletter as you have expressed interest in finding out about shoreline issues and progress and participation opportunities as part of the 2016-2017 Update of the Ausable Bayfield Conservation Authority (ABCA) Shoreline Management Plan.

AUSABLE BAYFIELD CONSERVATION
CREATING AWARENESS | TAKING ACTION

Thank you for your interest in the Shoreline Management Plan Update.

Third Issue - August 2016

Shoreline Management Plan Update Newsletter

This is the third issue of the Ausable Bayfield Conservation Authority (ABCA) Shoreline Management Plan (SMP) Update newsletter.

Sixty people have subscribed to this online newsletter. We thank all of you for your interest in shoreline issues and this important work.

Want to stay informed?

If you are already a subscriber to the newsletter, thank you. If you are not yet a subscriber, and you are interested in receiving regular updates, we invite you to subscribe to the free electronic newsletter at the following link:

Shoreline Management Plan Update Newsletter

Subscribe

Shoreline Management Plan Update Consultants' Recommendation

Report to be posted online

Document to be posted by September 1 for 90-day public review and written comments between September 1, 2016 and December 1, 2016

After more than a year of detailed technical work, the consulting team has prepared a Draft Updated Shoreline Management Plan (Consultants' Recommendation Report) for consideration of Ausable Bayfield Conservation Authority (ABCA).

The new report was prepared by the consulting team led by Karen Wianecki, of Planning Solutions Inc., Judy Sullivan of Aqua Solutions 5 Inc., and Robin Davidson-Arnott, University of Guelph. Additional input was provided by Billy Singh of Terraprobe Inc., and Ryan Mulligan, of Queen's University.

Members of the team presented their report and rationale to the Steering Committee at a meeting in the Masonic Hall, Exeter on Tuesday, July 26, 2016.

The Steering Committee consists of representatives from industry, shoreline residents, property owner groups, and other stakeholders as well as municipal government and county staff.

The Steering Committee wanted to make sure that shoreline residents and other interested members of the public have time to review and comment upon the document.

Ausable Bayfield Conservation staff are to post the Draft Updated Shoreline Management Plan (Consultants' Recommendation Report) to the website at abca.on.ca by September 1, 2016 after the mapping has been completed and appendices have been added. We will let subscribers to this newsletter know when the document is uploaded. You are then invited to download, review, and provide written comments upon the document. A printed copy of the draft plan will also be available for review at local libraries and at the ABCA office, at 71108 Morrison Line, east of Exeter, for people who do not have convenient access to the Internet. Written comments on the Draft Updated Shoreline Management Plan (Consultants' Recommendation Report), or questions, may be sent to Alec Scott or Geoff Cade through the staff contacts page at abca.on.ca. You are also invited to phone 519-235-2610 or toll-free 1-888-286-2610.

After comments are received, reviewed, and considered by Ausable Bayfield Conservation Authority and the Steering Committee, the ABCA would work with municipalities and other reviewing bodies in 2017 to develop local implementation policies through a draft implementation plan.

For more information, read this news release: Consulting team presents Draft Updated Shoreline Management Plan Recommendation Report to Steering Committee; Committee asks that document be posted online for review, public comments

Cohesive Bluff Shorelines Discussion Paper

Erosion of Cohesive Bluff Shorelines is a discussion paper on processes controlling erosion and recession of cohesive shorelines with particular reference to the Ausable Bayfield Conservation Authority (ABCA) shoreline north of Grand Bend.

This discussion paper has been prepared by Dr. Robin Davidson-Arnott, Professor Emeritus, University of Guelph, July 11, 2016.

Download Erosion of Cohesive Bluff Shorelines Discussion Paper now for free.

Fact sheet for property owners

Ausable Bayfield Conservation Authority has contracted Terraprobe Inc. to prepare a fact sheet for property owners about shoreline slope stability risks, hazards, warning signs and indicators, and recommended best management practices. Drafts of this information product have been prepared and it is currently being revised to prepare it for publication. The fact sheet is to be finalized shortly. We will let subscribers to this newsletter know as soon as it is available.

A news release informing shoreline landowners about bluff erosion and other natural hazard issues in light of higher lake levels was released in April and can be found here: **Risks of more gully and bluff erosion; potential slope failure**

Public events to take place in 2017

We originally anticipated that the Shoreline Management Plan (SMP) would be updated and approved by November of 2016.

The Steering Committee has told us it is important to allow sufficient time for public access, comment, and to address the comments. For this reason, completion of the Shoreline Management Plan Update work is now extending into 2017.

Originally, public open houses were proposed for 2016. Those opportunities for the public to take part are now to take place in 2017.

Details of document posting and opportunity for comment

The Ausable Bayfield Conservation Authority is to post the Draft Updated Shoreline Management Plan (Consultants' Recommendation Report) to its website at abca.on.ca by September 1, 2016 after the mapping has been completed and appendices have been added.

Shoreline property owners and other interested people are invited to review the document, download it for free, and provide written comments on the draft plan. For a copy of the document, after it has been posted, visit the Shoreline Management Plan Update web page.

You are invited to download the document for free, review it, and provide written comments between September 1, 2016 and December 1, 2016.

The document will be posted online for comment to give people easy access and give people enough time to provide comments. A printed copy of the draft plan will also be available for review at local libraries and at the ABCA office, at 71108 Morrison Line, east of Exeter, for people who do not have convenient access to the Internet.

Written comments on the Draft Updated Shoreline Management Plan (Consultants' Recommendation Report), or questions, may be sent to Alec Scott or Geoff Cade through the staff contacts page at abca.on.ca.

You are also invited to phone 519-235-2610 or toll-free 1-888-286-2610.

Go to the abca.on.ca website and click on the Shoreline Management icon on the home page or use the search tool on the home page.

Climate Change Impacts on the Great Lakes Discussion Paper

A free discussion paper, available now for free download, is a document that identifies the potential impacts of climate change on coastal processes across the ABCA watershed.

Download Climate Change Impacts on the Great Lakes Discussion Paper now at this link.

Climate Change Impacts on the Great Lakes – a discussion paper on the potential implications for coastal processes affecting the SE shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority has been prepared by Dr. Robin Davidson-Arnott.

Our mailing address is:
Ausable Bayfield Conservation Authority
71108 Morrison Line
RR 3
Exeter, Ontario N0M 1S5
Canada
Add us to your address book

unsubscribe from this list | update subscription preferences

WEB SITE INFORMATION & LINK: http://www.abca.on.ca/page.php?page=shoreline-management

SHORELINE MANAGEMENT

Ausable Bayfield Conservation Authority (ABCA), a local Steering Committee, and a consulting team are working with the community to update the Shoreline Management Plan (SMP).

The ABCA's first Shoreline Management Plan was approved in 1994. It was created to help address shoreline hazards related to flooding, erosion, and dynamic beaches in ABCA watersheds. That plan, created with the help of the community, has reduced damage along the shoreline during severe storms and high water events. This plan was last updated in 2000. It is time to update this important plan again.

NEW – Erosion of Cohesive Bluff Shorelines – A discussion paper on processes controlling erosion and recession of cohesive shorelines with particular reference to the Ausable Bayfield Conservation Authority (ABCA) shoreline north of Grand Bend

Shoreline Management Plan 2000 - Cover

Planning & Permits

- Environmental Planning
- Development Review and Regulations
- Permits and Fees
- GIS and Mapping
- Flood Plain Management
- Drinking Water Source Protection
- Shoreline Management

Flood Messages
Click image below for more information

NORMAL

Low Water Advisories

This new document, ***Erosion of Cohesive Bluff Shorelines***, is a discussion paper on processes controlling erosion and recession of cohesive shorelines with particular reference to the Ausable Bayfield Conservation Authority (ABCA) shoreline north of Grand Bend. This discussion paper has been prepared by Robin Davidson-Arnott, University of Guelph, July 11, 2016.

Download a copy of this document at no cost now: ***Erosion of Cohesive Bluff Shorelines***

Discussion paper on potential impacts of climate change on coastal processes across ABCA watershed area

A new discussion paper is available for free download. This document identifies the potential impacts of climate change on coastal processes across the ABCA watershed.

Download Climate Change Impacts on the Great Lakes - A discussion paper on the potential implications for coastal processes affecting the SE shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority.

Discussion paper on potential impacts of climate change on coastal processes across ABCA watershed area

A new discussion paper is available for free download. This document identifies the potential impacts of climate change on coastal processes across the ABCA watershed.

Download Climate Change Impacts on the Great Lakes - A discussion paper on the potential implications for coastal processes affecting the SE shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority.

This document has been prepared by Dr. Robin Davidson-Arnott (Draft – Version March 31, 2016).

Newsletter

Receive regular updates by subscribing to our free electronic newsletter at this link:

Shoreline Management Plan Update Newsletter

For issues of the newsletter click these links:

Issue Two - May 2016 (PDF)

Issue Two - May 2016 (HTML)

Issue One - November 2015 (PDF)

Issue One - November 2015 (HTML)

What is a Shoreline Management Plan?

The objectives of a Shoreline Management Plan (SMP) are to develop and support solutions to current and future issues and problems along the shoreline. The primary focus of the Ausable Bayfield Conservation Authority Shoreline Management Plan is to address the shoreline hazards for flooding, erosion, and dynamic beaches and their impact on shoreline development.

The main objectives of this focus are:

i. to reduce or eliminate damage due to periods of erosion, flooding, and dynamic beach movement that may occur to development close to the shore of Lake Huron.

ii. to direct new development away from hazardous areas.

iii. to help protect existing development from potential impacts of new development.

This update is needed to meet our commitment to provide a consistent and up-to-date guide for development and municipal land use planning along the shoreline. The Shoreline Management Plan should reflect current mapping, legislation, policies, guidelines, technical information related to shoreline hazards, and current land use trends along the Lake Huron shoreline.

The Ausable Bayfield Conservation Authority has invited a Steering Committee, with representation from diverse shoreline and industry interests, to oversee the process to develop the Updated Shoreline Management Plan. We have also retained the services of an experienced consulting team to assist with technical work.

We thank everyone who took part in our online survey. This information is helping the Steering Committee to understand the concerns and issues you have identified.

You may also phone **519-235-2610** or toll-free **1-888-286-2610** or email Alec Scott or Geoff Cade through our staff contacts page.

Thank you in advance for sharing your thoughts and for helping an Updated Shoreline Management Plan be the best document it can be for the future of our watershed communities.

The map image at top of page shows the study area.

Shoreline Management Plan 2000

Download the 2000 Shoreline Management Plan at this link:

Download Shoreline Management Plan 2000 (PDF) 5 mb – Very large file

Please contact us if you require this plan in another format. Thank you.

Appendix C: ABCA Hazard Maps

For reasons of file size, the draft hazard maps are posted separately on the Shoreline Management Plan web page at abca.on.ca.

Appendix D: Statistical Analysis of Recession Data

Estimating Shoreline Recession Rates 1973-2007

A description of the methodology used to determine recession rates along the Ausable Bayfield Conservation Authority (ABCA) shoreline north of Grand Bend

Prepared by:

Adam Bonnycastle

and

Dr. Robin Davidson-Arnott

Department of Geography

University of Guelph

July 11, 2016

The following document outlines the methodologies employed to estimate 1973-2007 erosion rates. It is presented according to four main sections:

- Input Data
- Final Output Data
- Original Proposed Methodology – Absolute positioning
- Final Methodology – Scale based concept

INPUT DATA

- 1973 data retrieved from:
    - Great Lakes Shore Damage Survey, 1973. Government of Canada Catalogue No. FS 99-10/1975. ©Minister of Supply and Services, 1976. (Erosion Atlas)
- 2007 data supplied by Ausable Bayfield Conservation Authority (ABCA):
    - ShorelineErosion.gdb
        - Shoreline2007DerivedData
            - Toe2007
            - Top_of_bank
        - Shoreline_2010_Data
            - TOB_2010
        - Imagery: shore2007.ecw
        - Other datasets in geodatabase are available
- 2007 Statistics Canada Road Network File:
    - Geography Division, Statistics Canada, 2007 Road Network File, 92-500-XWE/F. The incorporation of data sourced from Statistics Canada within this product shall not be construed as constituting an endorsement by Statistics Canada of such product.

FINAL OUTPUT DATA

Note - XX notation represents data taken from images 77 – 80.

- ShorelineErosion_Bonnycastle_ABCA.gdb
    - Bonnycastle_RoadsToe_NAD83_UTM (polyline feature classes)
        - ABCA_Toe_2007_GulliesRemoved_Image79Image80
        - InlandRoads1973_Dissolve
        - RoadCentrelines2007_Dissolve
        - Toe_LowestContour_1973
        - Toe_LowestContour_1973_RobinEdits
    - Bonnycastle_Transects_NAD83_UTM (polyline feature classes)
        - ImageXX_1973RobinEdits_Transects_RoadToeSplit
        - ImageXX_2007_1973RobinEditsJoined
        - ImageXX_2007_Transects_RoadToeSplit
        - ***Images77_80Merged_2007_1973_Joined_RobinSmoothed***
    - Lake_Huron_XX_ImageLinks (tables)
    - Lake_Huron_XX_ImageRectified (raster images)
    -

ORIGINAL PROPOSED METHODOLOGY- ABSOLUTE POSITIONING

The original proposed methodology was to scan and register the 1973 data, and to use a comparison of the absolute location of 1973 Top of Bluff and 2007 Top of Bluff to generate 34-year recession rates. The following is a high-level overview of these methods, followed by a listing of issues encountered. Following this section, there is both a high-level and detailed description of the final methodology.

1. Scan Erosion Atlas pages @ 600 dpi, and crop to individual images and maps (Adobe Photoshop).
2. Register images based on Eastings/Northings and ABCA data (ArcGIS, 1st order polynomial).
3. Register map to image (ArcGIS, 1st order polynomial).
4. Digitize Top of Bluff from registered maps (ArcGIS).
5. Compare 1973 Top of Bluff to 2007 Top of Bluff (ArcGIS).
6.

ISSUES ENCOUNTERED (PRESENTED AT PROJECT COMMITTEE MEETING JANUARY 14th, 2016)

- Visible shift between image and Easting-Northing grid causes unreasonably high registration residual error.
- Minimal registration links using 2007 roads and/or imagery:
    - Relatively few 'stable' features apparent at both years
        - Generally only major roads paved @ 1973.
        - 1973 imagery smaller scale, hard to determine if buildings at similar location actually the same building for each time.
    - Relatively long & narrow images → poor link distribution
        - Registration links based on features arranged in linear patterns, need to be well distributed
        - Larger absolute error in areas where registration is extrapolated, such as the shoreline at image overlaps.
    - Potential work-around: Use Whitebox GAT (http://www.uoguelph.ca/~hydrogeo/Whitebox/) to auto-mosaic sets of images, then register resulting mosaicked data. However,
        - Too little image overlap to produce reasonable results
        - Few tie points identified, arranged linearly → skewed mosaic
    - Very few registration links between map and image

FINAL METHODOLOGY – SCALE BASED CONCEPT

Due to the above issues that were encountered, the following scale-based concept was agreed to at the January 14th, 2016, meeting.

The ultimate goal of this work is to obtain recession data for the period 1973-2007, not the absolute position of the bluff toe or top. With this in mind, it is possible to accept the final scale of the 'registered' images as being reasonably accurate, and to measure change in distance between the toe of bank and major north-south inland roads at each time (1973, 2007). In effect the base line for the generation of transects at 50 m intervals perpendicular to the shoreline was taken as the centre line of Hwy 21 (Bluewater Highway) and this was digitized separately on the 1973 scanned images and the 2007 ABCA imagery.

Trials show that scale error changes with distance over which the measurement is taken:

- Negligible at whole-image scale (measured along-shore)
- ~3-5% at shore→road scale necessary for this study

This high-level overview of the final methodology is broken into more detail below:

1. Georeference Erosion Atlas imagery
2. Digitize features from ‘registered’ 1973 imagery
    a. Major inland roads running along-shore (almost entirely the Bluewater Highway)
    b. Toe of bank, generally assumed to be lowest contour from 1973 imagery
3. Digitize major inland roads running along-shore 2007 ABCA imagery, to match 1973 features. Even though ABCA imagery provided as a mosaic, it is important to start/end lines as close a match to the image-by-image 1973 lines as possible, in order to ensure that subsequent transects match as closely as possible.
4. Create evenly-spaced perpendicular transects along inland features for both years, long enough to extend into Lake Huron. It is not advisable to create one set of transects and use them for both times, since the overall orientation of the 1973 data may be slightly different than the 2007 data.
5. Remove all 2007 transects that interact with 2007 gullies, which are not included in 1973 data.
6. For each of the 1973 and 2007 data, split transect lines with toe of bank features, and delete all extraneous transect sections that are either inland of the road or in the water. This leaves transects only between the road and the toe of bluff.
7. Calculate lengths of remaining transect sections for each year.
8. Spatial join 1973 transects to 2007 transects, using maximum search radius to negate mis-joins.
9. **Rate of Change = $(Length_{2007} – Length_{1973})/(2007-1973)$**

The following three figures illustrate the process:

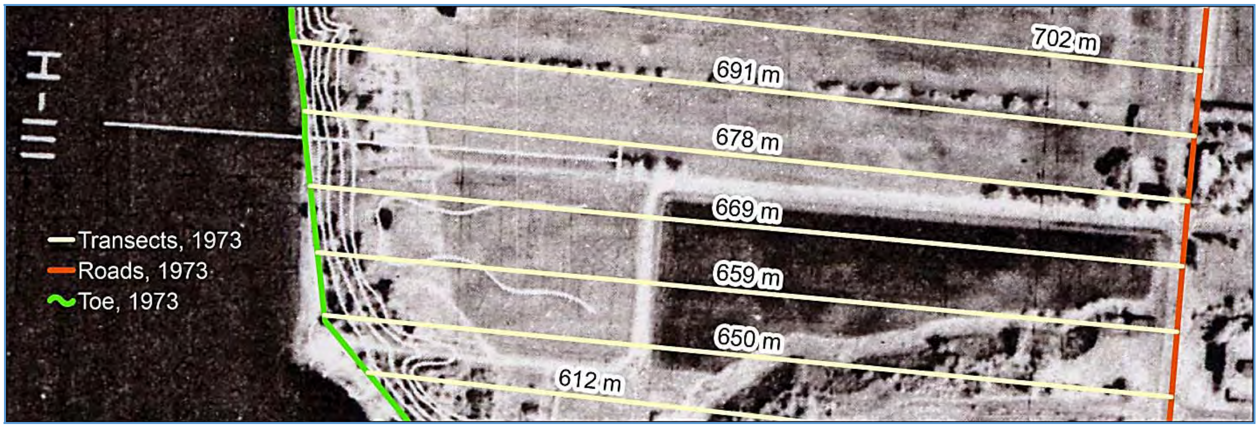

Figure 1 Example of 1973 transects

Figure 2 Example of 2007 Transects

Figure 3 Example recession rates

GEOREFERENC EROSION ATLAS IMAGERY

For each Erosion Atlas page for Study Area:

a. Scan page @ 600 dpi
b. Crop to aerial imagery portion (Adobe Photoshop)
c. Apply ArcMap Georeferencing functionality (1^{st}-order polynomial) to georeference cropped images. Store registration links in tables:
    - **Lake_Huron_77_ImageLinks**: Total RMS Error = Forward 3.36 m
    - **Lake_Huron_78_ImageLinks**: Total RMS Error = Forward 3.91 m
    - **Lake_Huon_79_ImageLinks**: Total RMS Error = Forward 5.23 m
    - **Lake_Huron_80_ImageLinks**: Total RMS Error = Forward 8.66 m
d. Use ArcMap Georeferencing functionality to permanently rectify georeferenced images @ 0.85 m cell resolution. Resolution chosen based on sample of pixel measurements of georeferenced imagery. Note that this process does NOT produced a true orthorectified product.
    - **Lake_Huron_77ImageRectified**, … ,**Lake_Huron_80ImageRectified**

PREPARE TOE OF BLUFF AND INLAND FEATURES

1. Digitize 1973 Toe of Bluff according to lowest visible contour @ 1:5,000 scale (larger where necessary to differentiate lowest contour from surrounding features.
    - **Toe_LowestContour_1973**
2. Digitize 1973 inland roads for each Erosion Atlas image that covers study site. Generally Bluewater highway. Dissolve features according to input image.
    - **Inlandroads1973_Dissolve**
3. Digitize 2007 inland roads to match from ABCA **shore2007.ecw**, using the Statistics Canada 2007 **Road Network File** to supplement areas where the ABCA imagery does not include the Bluewater Highway. Start and finish of the digitized lines to correspond as closely as possible to 1973 lines (for matching transects later). Dissolve features according to corresponding Erosion Atlas image.
    - **RoadCentrelines2007_Dissolve**
4. Copy ABCA **Toe_2007** layer and manually remove upland lines from areas covering Erosion Atlas images 79 and 80.
    - **ABCA_Toe_2007_GulliesRemoved_Image70Image80**

TRANSCENT CALCULATIONS – PRELIMINARY

Image 80 note – The curve of the Bluewater Highway in Image 80 was too great to allow transects at that location due to overlap. In order to minimize the lost area, transects for this image were processed as two groups North and South of the bend.

1. Create 1973 transects. For each Erosion Atlas study image (Images 77 – 80):
    a. Select the image line from **Inlandroads1973_Dissolve.** Use the ArcGIS add-in tool "Transect" (http://gis4geomorphology.com/stream-transects-partial/) to create 2000 m transects at 50 m spacing along selected feature**.** Tool more stable writing output as shapefiles, which were imported to geodatabase after the fact. Add a **Type** field (text) to hold information that lines are transects.

b. Select the image line from **Toe_LowestContour_1973**. Run ArcGIS **Feature to Line** using the selected toe, road, and transects as inputs. This splits transects across the toe and road lines.
    - **Image77_1973_RoadToeSplit**, … ,**Image80_1973_RoadToeSplit**

c. Edit and delete all non-transect lines from ***_RoadToeSplit** (toe, roads, transect lines in water, transect lines inland of road).

d. Edit and delete all transect lines that are broken by any type of gully feature. All final lines should be single lines running from road to toe of bluff.

e. Add field (**Length1973**, integer) and calculate length (m) of final transect lines.

2. Create 2007 transects.
    a. Repeat process from Step 1 for 2007 data.
3. Calculate Recession/Accession rates. For each image set of 1973 and 2007 transects:
    a. **Spatial Join** 1973 data to 2007 data based on **Within_A_Distance** matching, where maximum search distance is 25 m.
        - **Image77_2007_1973_Joined**, … ,**Image80_2007_1973_Joined**

    b. Add field (**Delta**, integer) and calculate [Delta] = [Length2007] – [Length1973]
    c. Add field (**RatePerYea**, float) and calculate as [RatePerYea] = [Delta]/(2007-1973)

TRANSCECT CALCULATIONS – 1973 TOE OF BLUFF, EDITED

1. Robin assesses results, suggests edits to certain areas of 1973 Toe of Bluff lines
    - **Toe_LowestContour_1973_RobinEdits**
2. Repeat transect calculations for 1973 data using edited toe of bluff.
    - **Image77_1973RobinEdits_Transects**, … ,**Image80_1973RobinEdits_Transects**
    - **Image77_1973RobinEdits_RoadToeSplit**, … ,**Image80_1973RobinEdits_RoadToeSplit**
    - **Image77_2007_1973RobinEdits_Joined**, … ,**Image80_2007_1973RobinEdits_Joined**

FINAL EDITS AND SMOOTHING

1. Robin assess results, based on available imagery, suggests manual edits where necessary. Add field (**ProcessingNotes**, text) to store whether final **RatePerYear** is automated or manual, and any other specific notes.
    - Automated: RatePerYear calculated according to methodology listed above
    - Manual: Manually edit 2007 transect line to better match features as indicated by imagery. Re-calculate **Length2007** and update **RatePerYear** accordingly.
2. Merge results to one set of data for entire study area.
3. Robin conducts smoothing technique using ExcelResults stored in new field (**Smoothed**, Double) and joined back to transect features using **EndNorthing** field as key field.
    - **Images77_80Merged_2007_1973_Joined_RobinSmoothed**

SMOOTHING

The calculated value for recession at each transect is subject to random errors arising from both the precision of the technique and accuracy. In addition, we can expect that there will be spatial and temporal variations reflecting, for example, variations in the hardness of the till or the beach width. These variations tend to get smoothed out over time and thus in projecting the position of the toe of the bluff 100 years into the future a better estimate can be obtained by incorporating estimates of the recession rates from adjacent transects. A series of trials with differing weights and number of transects was conducted and it was determined that there was little effect when transects more than 100 m on either side were considered. The final smoothing routine used a total weighting of 3.5. In this the central transect (the one for which the smoothed value is being determined) is given a weighting of 1, the adjacent transects 50 m on either side are given a weighting of 0.75 each, and a weighting of 0.5 was assigned to the transects spaced 100 m on either side. In cases where large gullies produced gaps in the continuity of the transects the weighting was modified to reflect this. Both the raw data for each transect and the smoothed data are supplied in the data base.

Appendix E: Climate Change – Potential Implications – Discussion Paper

Climate Change Impacts on the Great Lakes

A discussion paper on the potential implications for coastal processes affecting the SE shoreline of Lake Huron within the jurisdiction of the Ausable Bayfield Conservation Authority

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March 31 2016

1.0: Introduction

The potential effects of (human induced) Global Climate Change are likely to be significant for a whole range of activities in the Great Lakes Basin from shipping, to hydroelectric power generation, to commercial and recreational fishing, and to coastal processes controlling erosion and deposition. It is now usual for the development of management strategies for any, or all of these activities to consider the potential effects of Global Climate Change resulting from increased levels of greenhouse gases in the atmosphere and what kinds of adaptation strategies might be needed to account for this. Such considerations, for example, form part of the assessment of the management of flows and lake levels in the IJC Upper Great Lakes Study (International Joint Commission, 2012) and of management plans for major cities situated on the Great Lakes such as Toronto and Chicago (e.g., Hayhoe et al., 2010). This discussion paper reviews aspects of Global Climate Change that may be important for shoreline management in the Great Lakes and in particular for the area managed by the ABCA. No attempt is made to review the theories related to the effects of increased emission of greenhouse gases into the atmosphere on the climate of the earth or some of the issues related to this. There is now a general consensus among most scientists that Global Climate Change is real and there is considerable information being provided by scientific modelling to predict the impact of this on global and regional climates over the next 100-200 years under a range of future emission scenarios (see IPCC 2013). Therefore the approach taken here is to assume that there is a very high probability that some form of climate change will occur and that it would be negligent not to take this into consideration in planning management strategies for the next 100 years.

In considering climate change effects it is useful to begin with a general definition of some terms related to climate. The term **weather** describes processes in the atmosphere and in particular processes that affect us at, or close to the earth surface over a short period of time (hours to days), and we describe or measure aspects of it in terms of air temperature, clouds, precipitation, wind speed and direction and so on. **Climate** refers to the summation of all weather over some substantial period of time on the order of decades to centuries, and perhaps millennia. A key assumption in defining climate is that it can be described by a variety of statistical measures such as the mean and standard deviation of various parameters. It is then possible to examine trends in these statistics over time to determine if the climate is stable or changing. Global Climate Change therefore focuses primarily on defining climate over the past one to two centuries and forecasting changes over the next one to two centuries.

While the primary effect of increased greenhouse gases in the atmosphere is to raise the average temperature of the atmosphere close to the ground, the dynamic nature of the controls on earth climate means that this increase in temperature is not uniform spatially or temporally – it will be larger at higher latitudes and it will also be larger in the winter than in the summer at higher latitudes. Differential heating and cooling of water versus land and the transfer of heat through ocean currents increases the complexities of the effects and the timespan over which change takes place. Increased temperature will also affect the nature of the general circulation of the atmosphere, likely affecting, for example, the tracks and intensity of mid-latitude cyclones and this in turn will affect the nature of precipitation events and the proportion of snow versus rain on an annual basis. Prediction of the effects of increasing greenhouse gas concentrations in the atmosphere has been explored for several decades by increasingly complex Global Climate Models or GCMs which are computer models that simulate the characteristics of the earth surface and lower atmosphere and compare the effects of different scenarios of atmospheric CO_2 on climate over the earth as a whole. There are now over 40 such models in operation and they may differ in the way they represent various processes or the degree of complexity in accounting for effects such as ocean currents with the result that there are differences between models in their outputs. The earth surface is represented in the model by grid cells that at the global scale have sides on the order of 150-300 km which means that the Great Lakes region may be represented by only a few grid cells and the complexities of the lakes and the bordering land surface are not well represented, particularly for predicting local precipitation and evapotranspiration and thus the effects on stream flow and lake levels. This problem may be addressed by various techniques for downscaling to more appropriate scales on the order of 10-30 km (e.g., Gula and Peltier, 2012; Wang et al., 2015) which give us the ability to assess what the potential effects might be on a range of climate factors affecting the Great Lakes. In addition to detailed scientific papers there are a number of recent reports that synthesise the state of knowledge on climate change in the Great Lakes Basin and adaptation strategies to these (e.g., Huff and Thomas, 2014; McDermid et al., 2015; In particular, here we address potential climate change effects on lake level, storm frequency and magnitude, littoral drift, cohesive coast erosion, and sandy beach and dune systems relevant to the management of the ABCA shoreline.

2.0 <u>Predicted Changes in Temperature, Precipitation, and Storm Events</u>

In this section we examine the predicted changes in key climate variables of temperature, precipitation and the frequency and magnitude of storm events. In the following section we will examine the effects of these on key coastal processes.

2.1 *Changes in temperature*

Over the past 60 years temperatures in the Great Lakes region have increased on the order of 1-2°C with the temperature increase generally being greater towards the north. There is a greater reduction in minimum winter temperatures than an increase in maximum summer temperatures, all effects which are generally expected under climate change scenarios (McDermid et al., 2015). These trends are predicted to continue through the end of the century (Figure 1) with mean temperatures increasing by 2-7°C in southern Ontario (McDermid et al., 2015) and as much as 6-8°C under some scenarios (Wang et al., 2015). The number of frost-free days will increase significantly and, while the increase in summer temperatures is smaller than in the winter it will still drive a greater frequency of extreme heat alerts. Confidence in these projections is generally high (McDermid et al., 2015). Increased temperatures will influence the temperature of lake waters, stratification and the timing of turnover (Trumpicas et al., 2009; 2015) and this may have

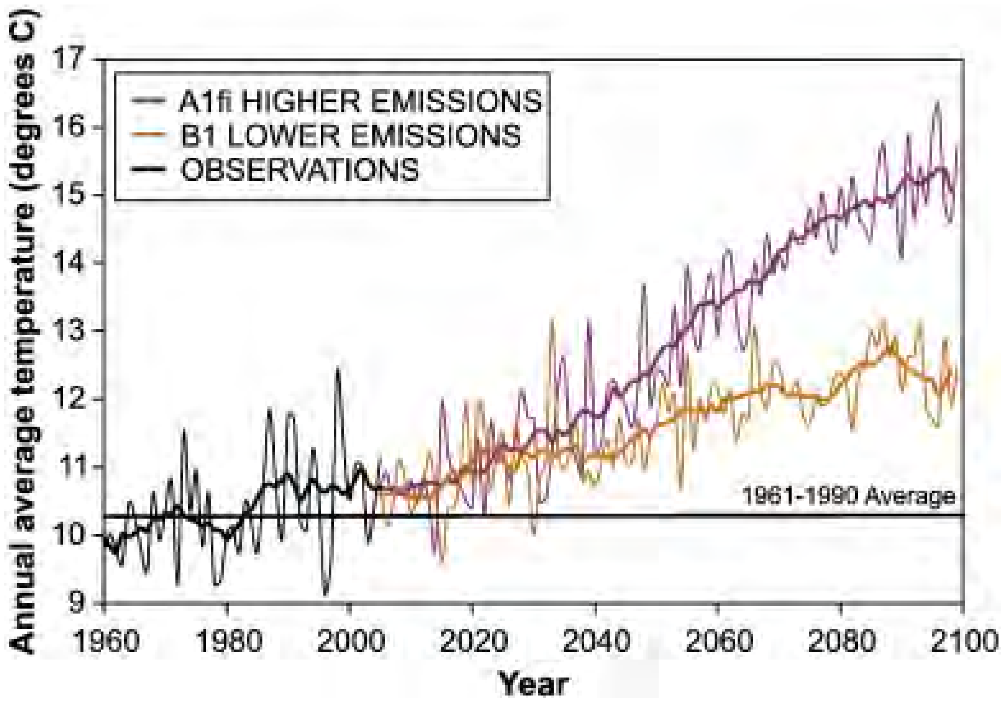

Figure 1: Observed and model-simulated historical and projected future annual average temperatures for Chicago, in degrees Celsius. Model simulations show the average of the GFDL 2.1, HadCM3, and PCM models for the SRES A1fi (higher) and B1 (lower) emission scenarios (after Hayhoe et al., 2012).

effects for example on fisheries (Lynch et al., 2010). It will lead to a very significant decrease in the extent and duration of winter ice cover on the lake and it will also have the potential to increase evaporation from the lake.

2.2 *Changes in precipitation*

There is much greater uncertainty in predicting changes in precipitation due to climate change than is the case for temperature. While there was a small increase in precipitation over the Great Lakes Basin in the last half of the 20th century this is likely within the range of variation and the first decade appears to have seen a decline. Future projections suggest an increase in the order of 20% by the end of the century with greater amounts towards the north compared to the southern half of the basin (Notaro et al., 2014; Wang et al., 2015; McDermid et al., 2015; Bartolai et al., 2015) but there is a great deal of uncertainty in this projection. There is, however general agreement that the proportion of precipitation falling as snow will decrease and there will be an accompanying decrease in the duration and depth of snow cover. Lake effect snowfall with probably decrease in southern Lake Huron in December and January but may increase slightly in mid to late winter (Notaro et al., 2015). Heavy downpours have been increasing in the basin and this is expected to continue through the 21st century (McDermid et al., 2015).

The small projected increase in precipitation may offset all or some of the projected increase in evaporation as a result of higher temperatures. This makes assessment of the effect on mean lake level more uncertain. Heavier rainstorms and a switch to rain rather than snow in late fall and early winter may increase erosion of cohesive bluffs.

2.3 *Changes in storms, storm tracks and winds*

There is some suggestion in the literature that average wind speeds will increase slightly and that wind speeds during storm events may be stronger (e.g., Peck et al., 2012; Wang et al., 2014). However, there does not seem to be enough certainty on this to project the impact on coastal processes. In any event, changes to wave generation and storm surge are limited by the existing shoreline configuration and water depth so that small changes in wind speed are not likely to have a significant effect. A significant change in wind direction, e.g., fewer storms with strong NW winds, might alter the littoral drift pattern and rate of bluff erosion but again the effect is likely to be small because of the position of the ABCA shoreline at the south end of the lake.

3.0 Climate Change Effects on Coastal Processes Within the ABCA Shoreline.

Changes in temperature and precipitation predicted under various Climate Change scenarios will have varying influences on coastal processes at the south end of Lake Huron. In this section we consider potential effects on lake level, wave climate, littoral sediment transport, erosion of cohesive bluff shorelines and aeolian sand transport.

3.1 *Mean and range of fluctuation in the level of Lake Huron*

Mean lake level and the range of fluctuations of the Lake Huron/Michigan Lake respond primarily to precipitation and evaporation /evapotranspiration over the lake and its basin. In addition because of the inflow from Lake Superior precipitation and evapotranspiration over that basin also have an effect. Ice jams at the entrance to the St. Clair/Detroit River during the winter may also affect flows and thus affect lake level for periods of months. The increased temperatures and reduced ice cover predicted by Climate Change models all suggest that there should be an increase in losses through evaporation from the lake and to supplies from rivers and groundwater through evapotranspiration. However, because recent modelling suggests an increase in precipitation, particularly in northern areas of the basin and over Lake Superior there is uncertainty as to the extent to which the losses through evaporation and evapotranspiration will be offset by increased supply (Angel and Kunkel, 2009; IJC Upper Great Lakes Study 2012; MacKay and Seglenicks, 2013; Bartolai et al., 2015). The prolonged period of low lake level between 2002 and 2012 was attributed by some as evidence of the impact of Climate Change but the recent increase in levels in Lake Superior and Lake Huron/Michigan have suggested that this was simply part of the long-term lake level fluctuation. Given the absence of any strong evidence for significant change under the climate change scenarios it is perhaps best to assume that mean lake level will remain within historic limits, or perhaps decrease slightly, and that there will continue to be decadal-scale fluctuations.

Changes in precipitation and winter ice cover may lead to a change in the seasonal lake level cycle with somewhat lower levels at the end of the summer and higher levels in the winter (MacKay and Seglenicks, 2013 see Figure 2).

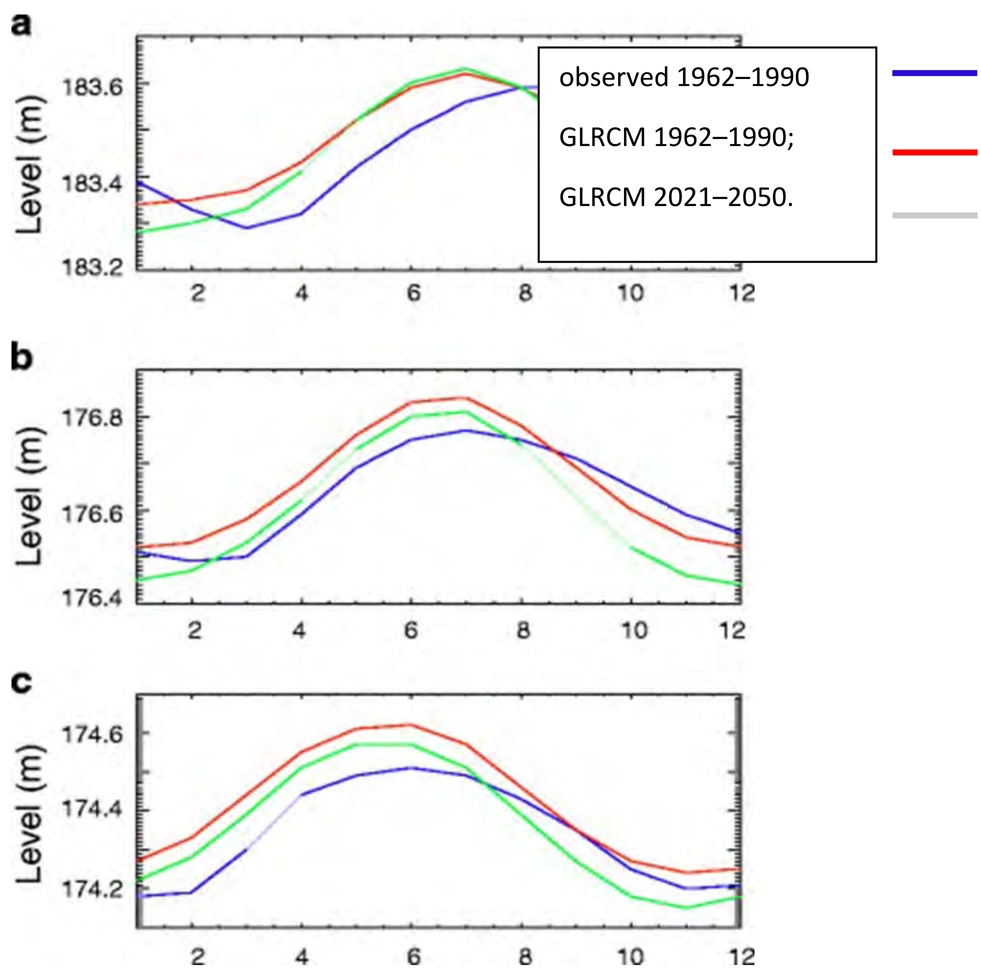

Figure 2: Lake level mean seasonal cycle for: a Lake Superior; b Lake Michigan – Huron; c Lake Erie. Units are m referenced to the International Great Lakes Datum 1985 (after MacKay and Seglenick, 2013, Figure 4).

3.2 *Storm frequency, magnitude and wave climate*

As noted above, there is little information on potential changes in storms and wind regime over the Lake Huron basin (Cheng et al., 2012) and no real indication that this will have a significant impact on the wave climate. However, the marked increase in temperature, particularly winter temperatures, is already producing a decrease in extent of ice cover during winter as measured by a decrease in the length of the ice season and in the thickness and extent of ice cover (Howk, 2009; Wang et al., 2012; see also Brown and Duguay (2010) for a review of the factors controlling ice formation and the duration of the ice season). Wang et al. (2012) found a significant decrease in annual lake ice coverage for all the Great Lakes for the period 1973-2010 averaging about 2% per year for Lake Huron over that period (Figure 3). The analysis of Wang et al. also shows that the large inter-annual variation in lake ice occurs at periods of about 8 and 4 years. These periodicities are likely linked to major global pressure indices (Bai et al., 2010). The 8 year oscillation is linked to AO/NAO (Arctic Oscillation/ North Atlantic Oscillation) and associated with cold conditions and very large ice cover; the 4 year periodicity is linked to ENSO (El Nino Southern Oscillation) and is associated with mild winters and small ice cover.

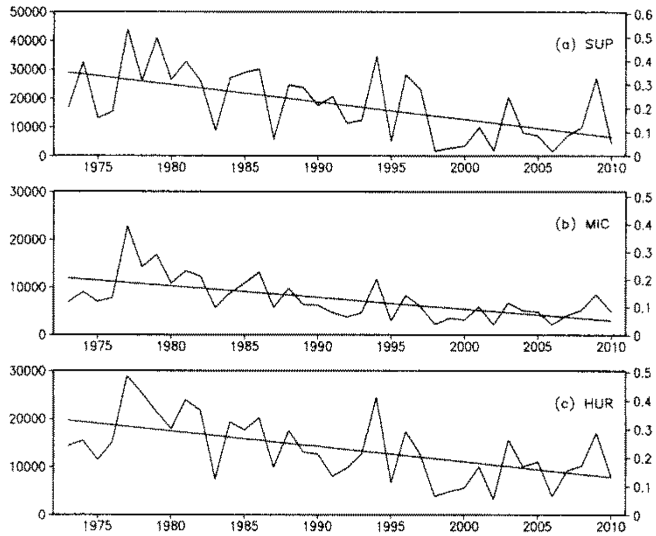

Figure 3: Annual mean lake ice area (km^2) for Lakes Superior, Michigan and Huron for the period 1973-201 and least squares trend line (from Wang et al., 2012, Figure 5).

The predicted increase in air and lake temperatures in the 21st century will lead to further decreases in the extent and duration of ice cover on Lake Huron. Modelling by Notaro et al. (2015) shows a decrease in maximum ice cover in February from the present level of about 50% to about 40 % by mid-century and 25% near the end of the century (Figure 4). The decrease in the duration and extent of ice cover will have a significant effect on the wave climate of southern Lake Huron because it will permit wave generation by an increasing number of storms in December and January, and again in March and April when ice cover in the lake under conditions at the turn of the century would usually have prevented this. The result will be an increase in the total annual wave energy. The effect may be magnified because these periods are often associated with more intense storms than in the middle of the year. The increase in the number of storms that generate significant waves during the year will likely have a significant impact on sand transport by wave action, the net littoral drift, and erosion of the nearshore profile and the bluff toe on cohesive shores.

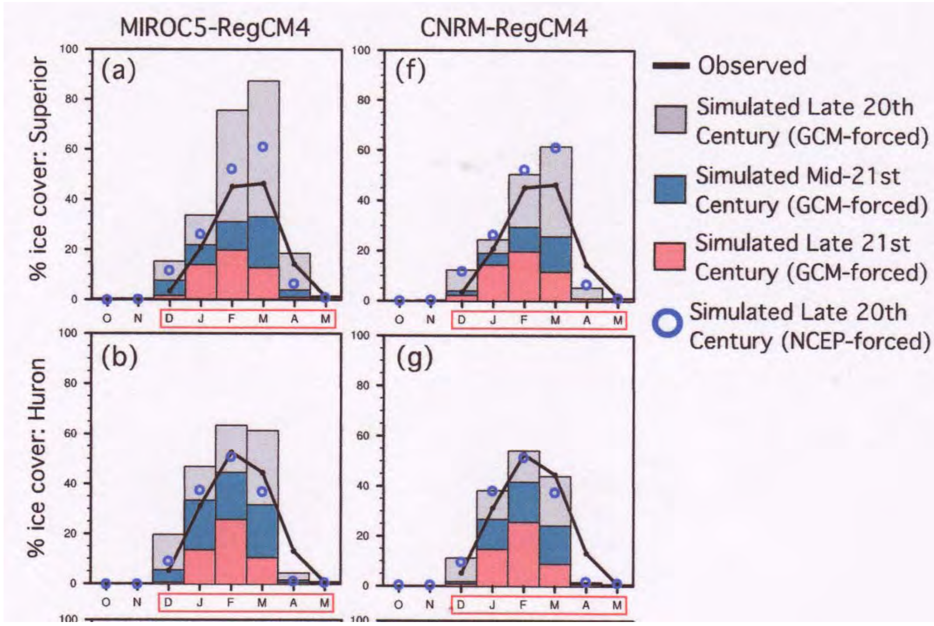

Figure 4: Mean seasonal cycle (October–May) of percent lake ice cover across Lakes (a),(f) Superior and (b),(g) Huron, from NOAA's Great Lakes Ice Atlas (black line) and from (left) MIROC5-RegCM4, (right) CNRM-RegCM4, and NCEP-RegCM4. Simulated results for the late twentieth century (1980–99) are shown with gray bars for MIROC5-RegCM4 and CNRM-RegCM4 and blue circles for NCEP-RegCM4. Simulated results for the late (mid) twenty-first century (2080–99) from MIROC5-RegCM4 and CNRMRegCM4 are shown with pink (aqua) bars. Red rectangles in the x axis indicate time periods with significant (p, 0.1) reductions in mean ice cover by both mid- and late twenty-first century (from Notaro et al., 2015, Figure 8).

3.3 Littoral drift magnitude and patterns

The southerly transport of sediment within the ABCA shoreline is driven by its position at the south end of the lake and the dominance of waves from the NW blowing over the longest fetch. That general pattern is therefore not likely to change, but the magnitude of net longshore transport is likely to increase and, depending on the relative magnitude and duration of winds from the north quadrant during the period which is now normally ice covered, these may be significant changes – possibly on the order of 20-30%. An example of the differences between high and low ice cover winters is shown in the work of BaMasooud and Byrne (2012). At Point Pelee on Lake Erie they measured much higher rates of erosion during the winter of 2005-06, which was characterised by very low ice cover, compared to very little erosion during the winter of 2003-04 which was characterised by very extensive ice covered that persisted for much of the winter. Mattheus (2014) also noted a similar role for ice cover in explaining changes in sedimentation at beaches on the south shore of Lake Erie.

Advances in modelling wave transformation and nearshore sediment transport have greatly improved our ability to model transport by waves (Figure 3). Recent work by Manson et al. (2016a, b) and the addition of a version of Delft 3D modified to include a new algorithm for simulating the effects of wave attenuation by ice provides a means of testing the effect of reduced ice cover on all coasts where ice is present in winter. Preliminary results for the north shore of Prince Edward Island show that reduced ice cover in the Gulf of St. Lawrence could lead to an increase in mean sediment transport by 50% or more (Manson, G., personal communication March, 2016) and it is likely that the effect along the ABCA shoreline would be of the same order of magnitude. The effect of this could be to reduce the volume of sand and gravel retained on beaches in the erosional sectors and thus a reduction in the beach width.

3.4 *Cohesive coast nearshore and sub-aerial bluff erosion*

Similar to the effect of reduced ice cover on nearshore sediment transport there will also be an enhancement of the rate of erosion of cohesive till in the nearshore because of the increase in the number of storm events on an annual basis. Most underwater erosion results from abrasion by sand and gravel rolling over the till surface under storm waves so that an increase in the number of storm events generating large waves will increase this process (Davidson-Arnott and Ollerhead, 1995; Davidson-Arnott and Langham, 2000). In turn, because the process of till erosion is irreversible, this will lead to an increase in wave energy reaching the bluff toe and ultimately to an increase in the rate of bluff recession. The magnitude of this increase is likely to scale with the increase in wave energy and so an estimate can be generated from the predicted pattern of decrease in ice cover and the average wind regime for those periods of the year during which wave generation in Lake Huron is presently inhibited by the presence of ice. The magnitude of this increase is likely to be on the order of 10-30% in the next few decades.

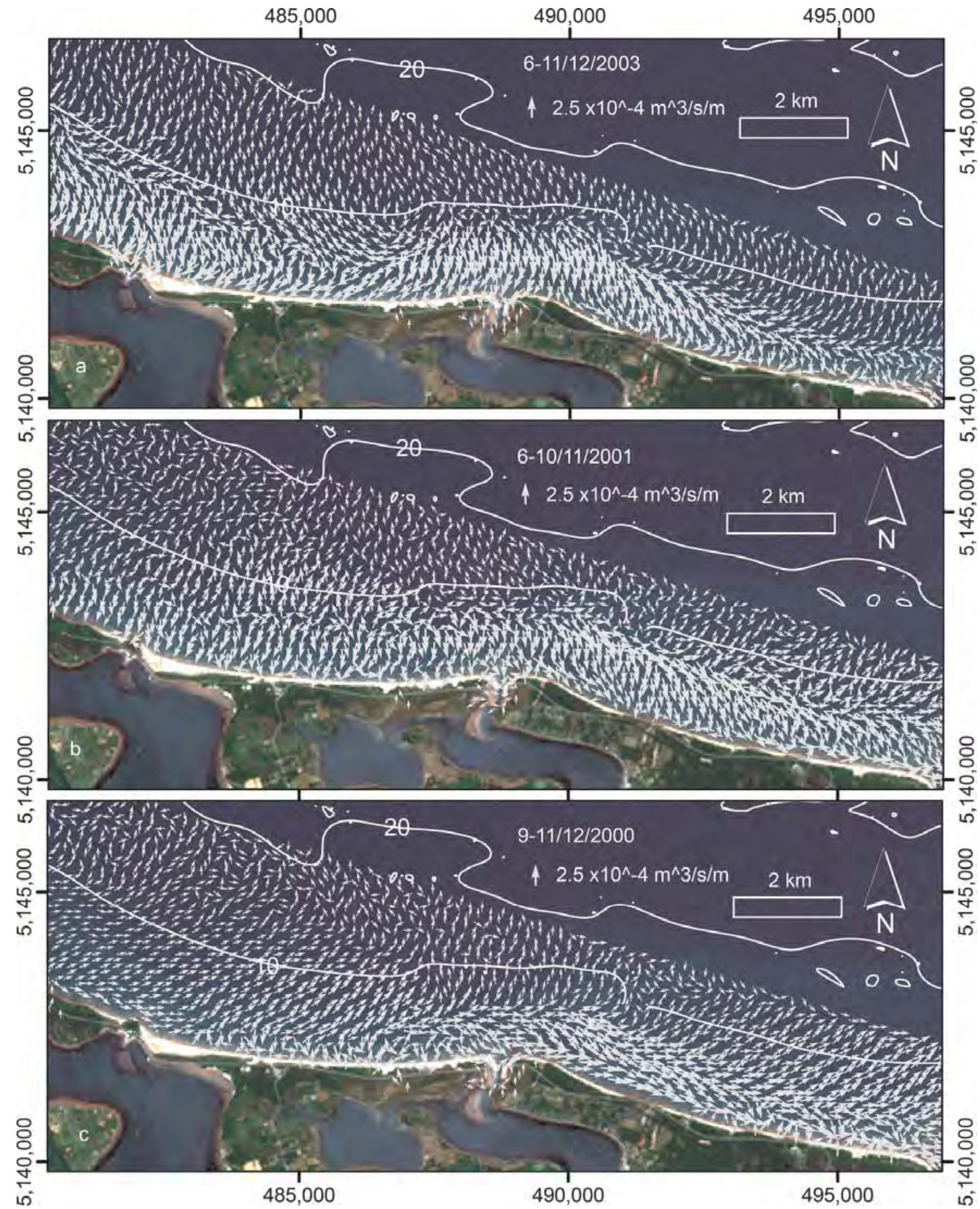

Figure 5: Example of the use of Delft3D hydrodynamic model to simulate sediment transport off the north coast of Prince Edward Island during open water conditions (Manson et al., 2016a). Shown are: a) mean bedload; b) suspended load; and c) total load transport with weighted mean transport directions during three fall storms. The arrows indicate the direction of transport and the length of the arrow is proportional to the mass of sediment transported.

3.5 Aeolian sand transport and coastal dune formation and stability

Reduced snow cover and increased wave activity during the winter may lead to an increase in the potential sand transport into the foredune zone in the dynamic beach area which stretches from Oakwood to Port Franks. This will be offset somewhat by wetter conditions and rainfall and by the enhanced potential for wave erosion during major storm events. The direct impacts of effects of climate change on coastal foredune plant communities are likely to be relatively small and difficult to predict locally because of the dominance of controlling factors, such as burial by sand and heat stress, and the relative resiliency of the plants in that zone (Reed et al., 2010). It is likely that marram (*Amophila breviligulata*) will continue to be the dominant species colonising the embryo dune and foredune zones since it is well adapted to somewhat warmer temperatures and is tolerant of sand burial and the hotter conditions that may prevail in the summer months.

Greater exposure to intense storms may also lead to more frequent dune erosion and rebuilding cycles, leading to shorter times for foredune recovery and the potential for more sand to be transported onto the crest and lee slopes of the foredune. However, the impact of this disturbance should be contained within the primary foredune zone and have little impact on the area landward.

3.6 *Adaptation to predicted impacts of Climate Change*

The predicted effects of Climate Change will have an impact on coastal processes along the southern Lake Huron shoreline, with the most important impacts likely being an increase in the rate of longshore sediment transport north of Grand Bend and an increase in the rate of downcutting in the nearshore and bluff toe erosion along the cohesive coast sections. At this time the predicted impacts on coastal processes are significant, but represent relatively modest changes to the magnitude of the operating processes within the existing system **not** a catastrophic change to the system itself. Nevertheless, it is important to consider them in assessing the existing policies and framework of the Shoreline Management Plan for the ABCA and what changes might be needed to strengthen these in the development of a revised an updated plan.

The timing and magnitude of these effects due to Climate Change is uncertain but there is also considerable uncertainty in our understanding of the processes themselves and our ability to predict the exact nature of coastal evolution over the next century and the scale of hazards due to erosion and to flooding associated with periods of above average lake level and storm surge. The general framework for shoreline management within the Provincial Policy is designed to be sufficiently flexible to accommodate these uncertainties by providing a sufficiently large buffer for setbacks of new development so that there is adequate time to accommodate short-term variability in the controlling processes as well as longer-term changes to the mean values. In particular, the use of a 100 year time horizon for recession rates and a 100 year flood elevation for lake level and storm surge should provide sufficient protection against the existing hazards as well as accommodating changes due to the predicted effects of Climate Change. In particular, if there is an increase in the recession rate along the cohesive bluff shoreline this can be detected in decadal shoreline change mapping and accommodated through revisions to the average annual recession rate so that the setback for new development is adjusted to the new rate. Similarly, the setbacks already in existence on dynamic beaches in the ABCA should be able to accommodate any changes that do occur along those sections of the shoreline. In summary, while the effects of Climate Change are significant, they can be accommodated within the existing management framework and it is important not to focus on this to the exclusion of the other factors, particularly human factors, that together control the nature of coastal hazards and ecological integrity within the shoreline managed by the ABCA.

4.0 Conclusions

1). Average annual temperatures in the region will likely increase on the order of 2-7°C by the end of the century with much of this resulting from a large increase in winter temperatures and a somewhat smaller increase in summer temperatures. In turn this will have an impact on lake temperatures, lake effect snowfall, winter ice cover and fish habitats. It will likely also have an impact on the length of the recreational season.

2) Precipitation is predicted to remain approximately the same or to increase by up to 20%, mostly in the northern half of the basin. Because of the warmer temperatures more precipitation will fall as rain rather than snow, and there may be more frequent heavy downpours. Confidence is much lower in these predictions than for temperature. The number of intensive storm may rise.

3) Because of the large uncertainty with respect to predictions for precipitation and evapotranspiration it is difficult to predict what will happen to mean lake levels. Recent modelling suggests that they will likely remain similar to historical levels.

4) The duration and extent of ice cover in southern Lake Huron had already decreased and is predicted to decrease further by the end of the century. The most important impact of this longer ice-free season on coastal processes will be an increase in the number of storms associated with large waves and large storm surges. This effect is enhanced by the fact that storms during the winter months are generally more frequent and more intensive than spring and summer. In turn, the greater frequency of storms and increased number of intense storms will drive larger volumes of longshore sediment transport and an increase in the rate of downcutting of the nearshore and erosion of the bluff toe along cohesive shorelines. There may be some changes in the vegetation along sandy beaches and the potential for some increase in sand transport from the beach to the foredune and the frequency of events leading to erosion of the foredune.

5) The potential for enhanced rates of longshore sediment transport and bluff erosion as well as impacts on the dynamics of sandy beach and dune systems can be addressed within the general framework of the shoreline management plan and the Provincial Policy. However, it will require increased vigilance to ensure that the average annual recession rates are updated regularly as new aerial photography, and possibly LiDAR, become available.

References

Angel, J. and Kunkel, K., 2009. The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan - Huron. Journal of Great Lakes Research 36, 51-58.

Bai, X., Wang, J., Sellinger, C., Clites, A. and Assel, R., 2010. The impacts of ENSO and AO on the interannual variability of Great Lakes ice cover. NOAA Tech. Memo. GLERL-152, 48 pp.

BaMasoud, A. and Byrne, M-L., 2012. The impact of low ice cover on shoreline recession: A case study from Western Point Pelee, Canada. Geomorphology, 173–174, 141–148.

Bartolai, A.M., He, L., Hurst, A.E., Mortsch, L., Robert Paehlke, R. and Scavia, D., 2015. Climate change as a driver of change in the Great Lakes St. Lawrence River Basin. Journal of Great Lakes Research, 41, Supplement 1, 45-58.

Brown, L.C. and Duguay, C.R., 2010. The response and role of ice cover in lake-climate interactions. Progress in Physical Geography, 34, 671-704.

Cheng, C.S., H. Auld, L. Qian and Guilong, L., 2012. Possible impacts of climate change on extreme weather events at local scale in south–central Canada. Climatic Change, 112, 963-979.

Davidson-Arnott, R.G.D. and Ollerhead, Jocelyn, 1995. Nearshore erosion on a cohesive shoreline. Marine Geology, 122, 349-365.

Davidson-Arnott, R.G.D. and Langham, D.R.J., 2000. The effects of softening on nearshore erosion of a cohesive shoreline. Marine Geology, 166, 145-162.

Gula, J. and Peltier, W.R., 2012. Dynamical downscaling over the Great Lakes Basin of North America using the WRF Regional Climate Model: The impact of the Great Lakes system on regional greenhouse warming. Journal of Climate, 25, 7723-7742.

Hayhoe, K., VanDorn, J., Crowly II, T., Schlegal, N. and Wuebbles, D., 2010. Regional climate change projections for Chicago and the US Great Lakes. Journal of Great Lakes Research, 36, 7-21.

Howk, F., 2009. Changes in Lake Superior ice cover at Bayfield, Wisconsin. Journal of Great Lakes Research, 35, 159-162.

Huff, A. and Thomas, A., 2014. Lake Superior Climate Change Impacts and Adaptation. Prepared for the Lake Superior Lakewide Action and Management Plan – Superior Work Group. Available at http://www.epa.gov/glnpo/lakesuperior/index.html. 139pp.

Intergovernmental Panel on Climate Change (IPCC), 2013. Summary for policymakers. In: Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

International Joint Commission, 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels. Final Report of the Upper Great Lakes Study, 216 pp.

Lynch, A.J., W.W. Taylor, W.W. and Smith, K.D., 2010. The influence of changing climate on the ecology and management of selected Laurentian Great Lakes fisheries. Journal of Fisheries Biology, 77, 1764-1782.

MacKay, M., and F. Seglenicks, F., 2013. On the simulation of Laurentian Great Lakes water levels under projections of global climate change. Climatic Change, 117, 55-67

Manson, G.K., Davidson-Arnott, R.G.D., Forbes, D.L., 2016a. Modelled nearshore sediment transport in open-water conditions, central north shore of Prince Edward Island, Canada. Canadian Journal of Earth Science, 53, 101-118, dx.doi.org/10.1139/cjes-2015-0090.

Manson, G.K., Davidson-Arnott, R.G.D. and Ollerhead, J., 2016b. Attenuation of Wave Energy by Nearshore Sea Ice: Prince Edward Island, Canada. Journal of Coastal Research, 32, 253-263.

Mattheus, C.R., 2014. Climate-Induced Changes in Rates of Headland-Beach progradation along the Southern Coast of Lake Erie. Journal of Coastal Research, 30, 743–755.

McDermid, J.L., Dickin, S.K.,Winsborough, C.L., Switzman, H., Barr, S., Gleeson, J.A. Krantzberg, G. and Gray, P.A., 2015. State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects. Prepared jointly by the Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry to advise Annex 9 - Climate Change Impacts under the Great Lakes Water Quality Agreement, October 2015.

Notaro, M, D. Lorenz, D., Hoving, C. and Schummer, M., 2014. Twenty-First-Century Projections of Snowfall and Winter Severity across Central-Eastern North America. Journal of Climate 27, 6526-6550.

Notaro, M., V. Bennington, V. and Vavrus, S., 2015. Dynamically Downscaled Projections of Lake-Effect Snow in the Great Lakes Basin. Journal of Climate 28,1661–1684.

Ontario Ministry of the Environment, 2009. Report of the Expert Panel on Climate Change Adaptation. Queen’s Printer, 89 pp.

Peck, A., Prodanovic, P. and S.P. Simonovic, S.P., 2012. Rainfall intensity duration frequency curves under climate change: city of London, Ontario, Canada. Canadian Water Resources Journal, 37, 177-189.

Reed, D.J,, Davidson-Arnott, R. and Perillo, G.M.E., 2009. Estuaries, coastal marshes, tidal flats and coastal dunes. In, Slaymaker, O., Spencer, T. and Embleton-Hamann, C. (eds) Geomorphology and Global Environmental Change. Cambridge: Cambridge, University Press, 130-157.

Trumpickas, J., B.J. Shuter and C.K. Minns. 2009. Forecasting impacts of climate change on Great Lakes surface water temperatures. Journal of Great Lakes Research, 35, 454-463.

Trumpickas, J., B.J. Shuter and C.K. Minns and H. Cyr. 2015. Characterizing patterns of nearshore water temperature variation in the North American Great Lakes and assessing sensitivities to climate change. Journal of Great Lakes Research, 41, 53-64.

Wang, J., Bai, X.Z., Hu, H.G., Clites, A., Colton, M., Lofgren, B., 2012. Temporal and spatial variability of Great Lakes ice cover, 1973–2010. Journal of Climate, 25, 1318–1329.

Wang, X., Huang, G., Lin, Q., Nie, X. and Liu, J., 2015. High-resolution temperature and precipitation projections over Ontario, Canada: a coupled dynamical-statistical approach. Quarterly Journal of the Royal Meteorological Society, doi: 10.1002/qj.2421.

Wang, X., G. Huang and J. Liu. 2014c: Projected increases in near-surface air temperature over over Ontario, Canada: a regional climate modeling approach. Climate dynamics, 45, 1381-1393.

Appendix F: Cohesive Bluff Erosion Discussion Paper

Erosion of Cohesive Bluff Shorelines

A discussion paper on processes controlling erosion and recession of cohesive shorelines with particular reference to the Ausable Bayfield Conservation Authority (ABCA) shoreline north of Grand Bend

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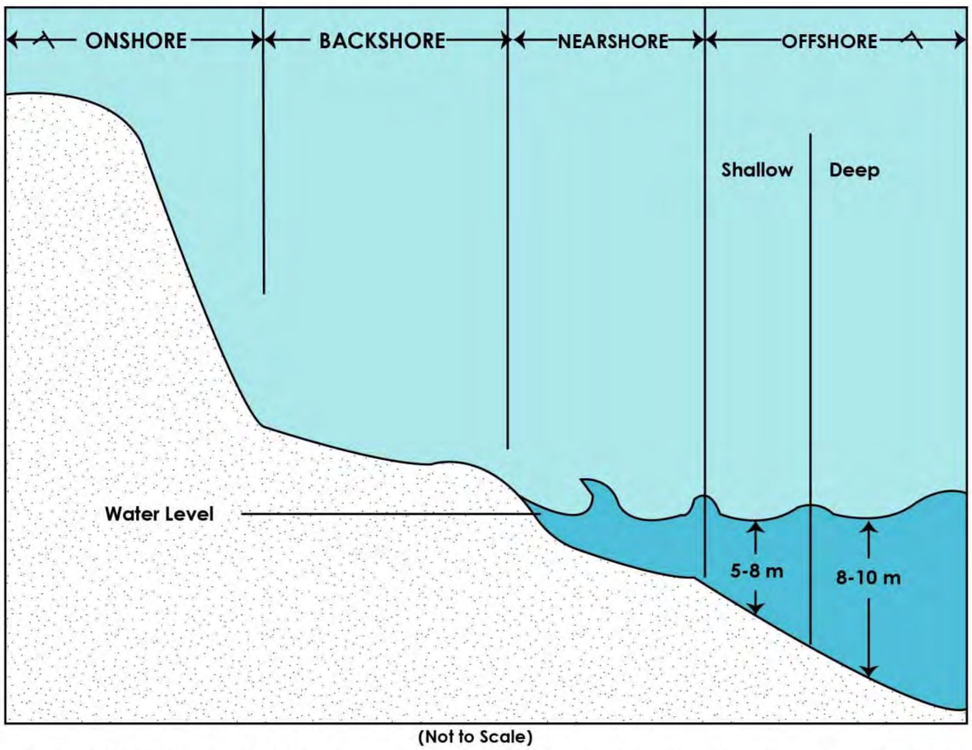
July 11, 2016

Source: Ausable Bayfield CA, 2015

Characteristics of Cohesive Bluff Shorelines

The term cohesive shoreline is used to describe cliff coasts where the profile on land and underwater is developed in sediments with a high silt and clay content. Cohesive bluff shorelines are characteristic of about 40% of the shoreline of the lower Great Lakes and are the dominant shoreline type on the east shore of Lake Huron from Point Clarke to Sarnia. They are relatively weak, or 'soft', and are susceptible to rapid erosion due to wave action (Hutchinson, 1986). It is convenient to distinguish three components of the cohesive coast system: 1) the bluff face which generally lies above the level of wave attack; 2) the bluff toe which is subject periodically to erosion by waves during large storms and occasionally during periods of high lake level may be continuously under water; and 3) the beach and nearshore profile which extends from the toe seaward to a depth of about 8-10 metres (m) where erosion by waves becomes negligible (Figure 1).



Source from MNRF Technical Guide-Part 1: Figure A1.2.1 Definition of the Shoreline Zone Page A1-2-2 (2001)

Figure 1 – Definition of Shoreline Zone. Note that the transition from the nearshore to the offshore is defined by the breaker line in this diagram but in the body of the paper it is defined by the limit of wave action on the bed which is about 10-12 m on the ABCA coast.

Erosion at the toe produces oversteepening of the bluff slope and triggers recession of the slope through shallow slides, mud flows, erosion by rain splash and surface runoff, and occasionally by deep-seated failures. Bluff recession rates are large compared to cliff coasts in hard bedrock, generally ranging from 0.3 m/y to as much as 2 m/y along parts of the north shore of Lake Erie. Within the northern portion of the Ausable Bayfield Conservation Authority (ABCA) shoreline Sideroad 30 in Goderich Township to just north of Grand Bend rates are generally low to moderate (0.2-0.6 m/y) and substantial in some areas where they may reach 1 m/y. The recession of the bluff shorelines is also accompanied by rapid evolution of the underwater profile and it is now recognised that the rate of horizontal bluff recession is in dynamic equilibrium with vertical lowering of the nearshore profile (Figure 2).

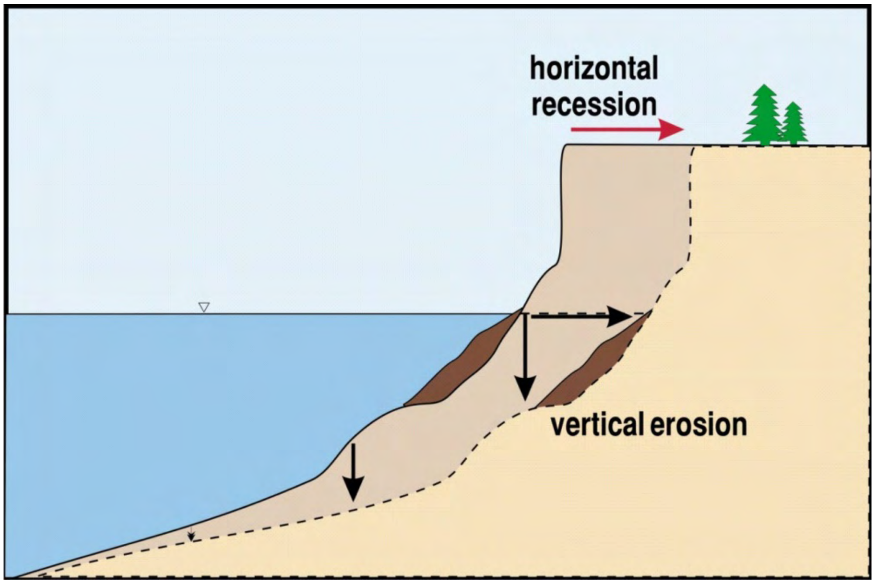


Figure 2: Equilibrium profile development on a cohesive bluff coast. Ongoing vertical erosion permits waves to continue to attack the wave toe as the bluff recedes and the two proceed in equilibrium (Davidson-Arnott and Ollerhead, 1995).

There is a large amount of literature on erosion and recession of cohesive bluffs or 'soft cliff' shorelines, including a lot of work on both sides of the border in the Great Lakes (e.g., Gelinas and Quigley, 1973; Quigley et al., 1977; Edil and Vallejo, 1980; Carter and Guy, 1988; Brown et al., 2005). In addition to material presented in the Technical Guide for Flooding, Erosion and Dynamic beaches in support of the Provincial Policy Statement (Ontario Ministry of Natural Resources, 2001), processes associated with erosion of these coasts are reviewed in Brew (2004), Hampton and Griggs (2004), Geomorphic Solutions (2010a) and Davidson-Arnott (2010, Chapter 13).

<u>Erosion of Cohesive Bluffs</u>

The bluffs in the ABCA area are formed almost entirely in glacial till deposited by ice moving out of the Lake Huron basin towards the end of the last ice age (about 25,000-15,000 years ago). The upper layer, which is exposed throughout the bluffs, is the St. Joseph Till composed of about 86% silt and clay eroded from the deep lake basin and the remainder varying amounts of sand, gravel and cobbles. Underlying this is another till called the stony till or Rannoch Till which has a much higher proportion of gravel and cobbles derived from erosion of the bedrock underlying the lake (Figure 3). In addition to cohesion due to the presence of clay, the till gets much of its strength from overconsolidation due to the pressure (weight) of the ice during deposition. In its unweathered form it is very dense and quite strong due to the friction between particles – so much so that it can form vertical cliffs for a short time.

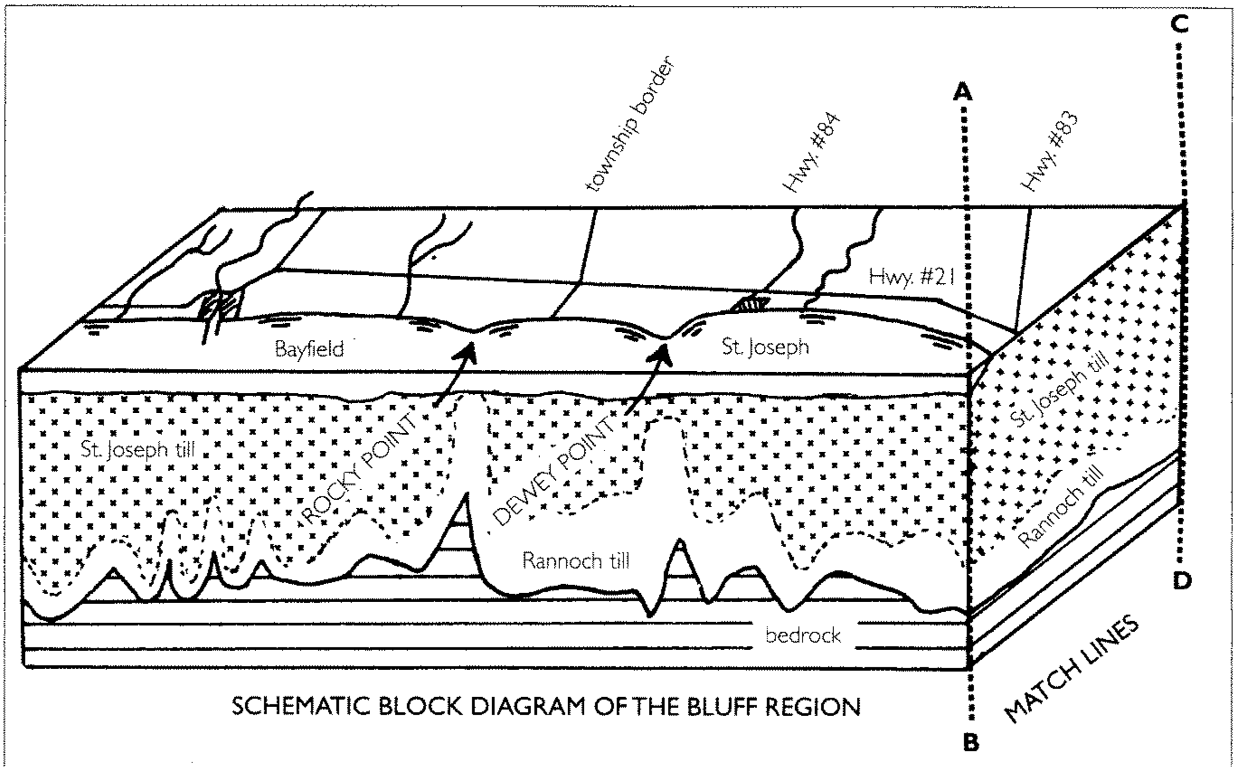


Figure 3: Schematic block diagrams of the northern cohesive bluff shoreline and southern sandy beach and dune shoreline within the ABCA jurisdiction (from Reinders, 1989)

It has been shown that over weeks and months the strength of overconsolidated clay tills decreases close to the surface due to expansion and to weathering processes such as wetting and drying and freeze-thaw action (Hutchinson, 1986 – see Figure 4, a,b; Figure 5). On the face of the bluff this weathered layer is subject to rapid erosion by rain splash, running water and the development of small rills where there is limited vegetation cover. In the spring and during heavy rainfalls it can become saturated and shallow slides and slumps take place bringing material to the toe of the bluff where it is easily removed by waves. As a result of the strength of the till, and the general absence of sandy units through which groundwater can flow, deep-seated failures are rare within the ABCA shoreline. Where the slope is protected by vegetation, and is not subject to overland flow of water and gully development, it can maintain a steep, stable slope as long as it is not subject to wave erosion at the toe. However, where there is wave attack on the bluff toe, undercutting of the slope leads to oversteepening leading to disturbance of vegetation and in turn this triggers the range of erosional processes noted above (Figure 5).

a)

b)

Figure 4: Weathering of till in cohesive bluffs, St. Catharines, Lake Ontario: a) bluff toe - wave erosion has removed weathered till in the right foreground and expansion cracks and fissures are just appearing. In the background small slumps have taken place in weathered material aided by snowmelt in the spring; b) drying of the surface layer in the summer produces a 'popcorn' surface of weathered silt and clay that is easily removed during heavy rains.

Figure 5: Desiccation cracks formed in a layer of weathered till leading to slumping of isolated blocks, ABCA shoreline

The rate at which erosion of cliff shorelines occurs can be viewed (Sunamura, 1983) as being a function of the relative strength of the 'assailing forces' (wave action) and the 'resisting forces' (the strength of the cohesive sediments in which the profile is formed). The controls on erosion of the bluff toe and underwater erosion are quite complex and not very easy to predict – see Figure 6. However, measurements of historic bluff toe recession rates do provide a good estimate of future rates at a point along the shoreline.

Erosion by wave action at the bluff toe results from forces associated with the wave itself (lower portion of Figure 6), notably wave impact when waves break on the bluff and from turbulence associated with waves running up the beach and the bluff face. While erosion of cohesive sediments can take place as a result of wave generated currents alone, most of the time this is enhanced by the movement of sand and gravel from the beach which acts to abrade the surface of the till and speeds up the process of erosion of the bluff toe (Sunamura, 1977; Kamphuis, 1990; Blanco-Chaco et al., 2007). At the bluff toe the relatively soft outer layer of weathered material eroded quite quickly by wave action during a storm but the rate of erosion slows down once the underlying harder till is exposed (Amin and Davidson-Arnott, 1995). However, in their study of erosion events in a till on the south shore of Lake Erie with a strength similar to that of the St. Joseph Till, Amin and Davidson-Arnott (1995) found that maximum erosion was generally <10 centimetres (horizontally). In the intervening period between storms weathering produces another layer of softened material which can then be eroded by the succeeding storm. Where waves do not reach the bluff toe for several years during periods of low lake level, a much deeper weathered layer develops and thus in the succeeding high water period erosion of the bluff toe may proceed quite rapidly as this thicker layer is eroded. Thus, while the magnitude of wave energy is an important control on the overall recession rate during an individual storm event (Buckler and Winters, 1983; Kamphuis, 1987) the time between storms is also important for allowing the weathering processes to act. Where the cohesive profile is formed in sands silts and clays that have not been overconsolidated, erosion may be much greater, as is the case for bluffs along much of the central north shore of Lake Erie where recession rates can be 1.5 to 2 m/y or more.

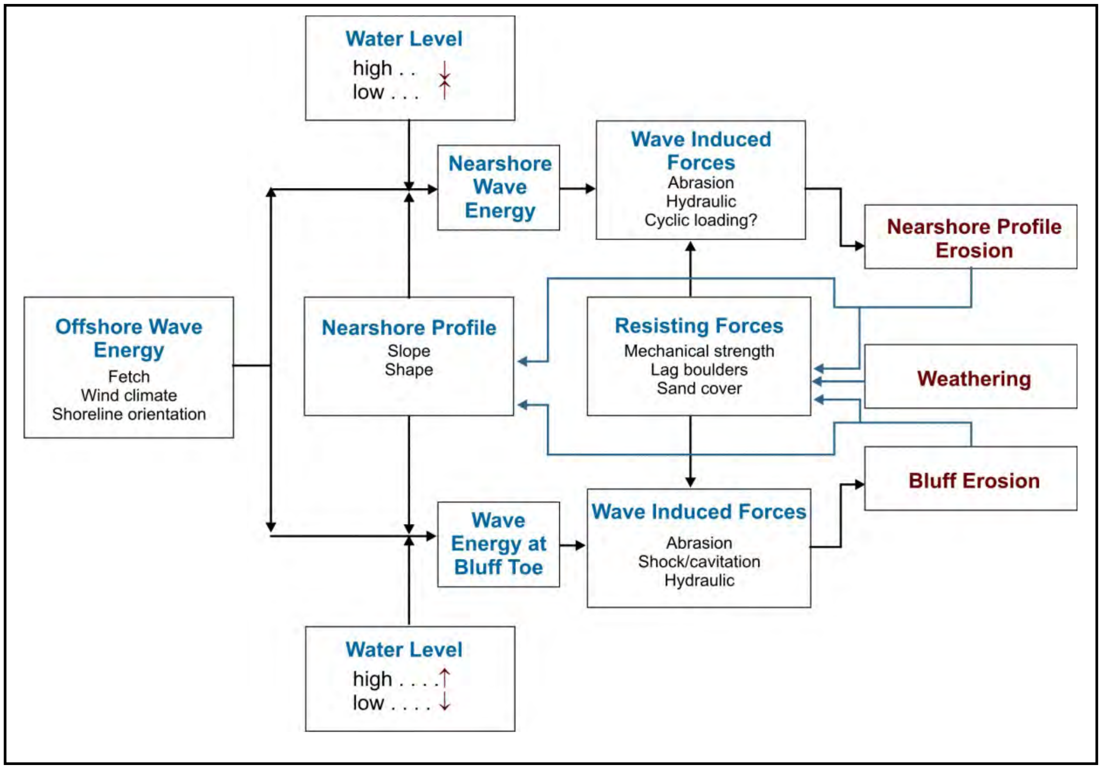


Figure 6: Processes controlling erosion of a cohesive coast. The upper and lower set of boxes relate to the ‘assailing forces’ on the nearshore profile (upper) and bluff toe (lower) while the centre part relates to the ‘resisting forces’. Weathering reduces the mechanical strength of the till both on land and underwater. Note also that high lake level is associated with increased bluff toe erosion while increased underwater erosion occurs with low lake level. (Davidson-Arnott, 1990, 2010; after Sunamura, 1983).

In the case of cliffs formed in hard bedrock toe erosion proceeds more slowly with higher cliffs because the rock material that builds up at the toe of the slope acts to protect it from wave action and it may take many years for weathering and abrasion by wave action to break up the material and move it alongshore and offshore. Measurements of bluff recession on cohesive coasts have generally found little correlation between recession rates and bluff height, likely because the material brought to the toe of the slope is so easily eroded (Buckler and Winters, 1983).It may also be that the role of height is not as easily identified where there is alongshore variation in beach width and thus in the degree of protection offered by beach sediments from wave erosion (Davidson-Arnott and Amin, 1985).

Within the tills that make up the cohesive cliff profile it can be expected that there will be vertical and horizontal variations in properties of the till, including sediment size, the proportion of silt and clay, the hardness of the material and also local permeability. All of these affect the rate at which weathering may occur and also the resistance to erosion locally at points along the shoreline (Joyal et al., 2016). Similarly these may affect the rate of underwater erosion of the till. In turn this may explain some of the local variations in bluff recession alongshore and the development of small, temporary, headlands as recession takes place.

Underwater erosion and vertical lowering of the profile

While toe erosion is the immediate control on bluff recession, it is now recognised that it in turn is controlled by the rate of erosion of the underwater profile which ultimately controls how much wave energy reaches the toe. While it is not as readily visible as is erosion of the bluff face and toe, it can be quite readily demonstrated if the amount of recession of the bluff toe over a period of years is known. Over a period of decades the average rate of downcutting can be estimated by measuring the water depth at a point where the bluff toe was located in the past and dividing by the number of years elapsed since the bluff toe was at that location (Healey and Wefer, 1980; Philpott, 1986). Thus if the bluff toe has receded at a rate of 1 metre per year over 100 years and the water depth at a distance of 100 metres from the present bluff toe (i.e., the position of the toe one hundred years ago) is 3.5m, then vertical erosion has occurred at an average rate of 0.035 m/y – or 3.5 cm a year.

Recession of the bluff face initially produces a wider platform on which wave energy is dissipated and thus maintenance of wave attack at the toe requires erosion of this platform to allow waves to continue to reach the toe (see Figure 2). Over a period of decades there is a dynamic equilibrium between vertical lowering of the nearshore profile and the rate of bluff recession and it is now recognised that the two proceed in dynamic equilibrium (Zenkovitch, 1967; Davidson-Arnott and Askin, 1980; Philpott, 1986; Nairn et al., 1986; Davidson-Arnott and Ollerhead, 1995; Trenhaile, 2009). As a result, if this assumption holds, it is possible to predict the rate of lowering of the nearshore profile at a point on the profile from the local slope and the recession rate of the bluff toe using the expression (Zenkovitch, 1967):

$$\frac{dy}{dt} = \frac{dx}{dt} tan\alpha \qquad \text{(equation 1)}$$

Where dy/dt is the rate of vertical lowering at a point y on the profile, dx/dt is the rate of horizontal recession of the bluff toe and tan α is the profile slope at point y. A comparison of measured rates of erosion underwater with rates predicted using this formula for a site near Grimsby on Lake Ontario shows good agreement (Figure 7).

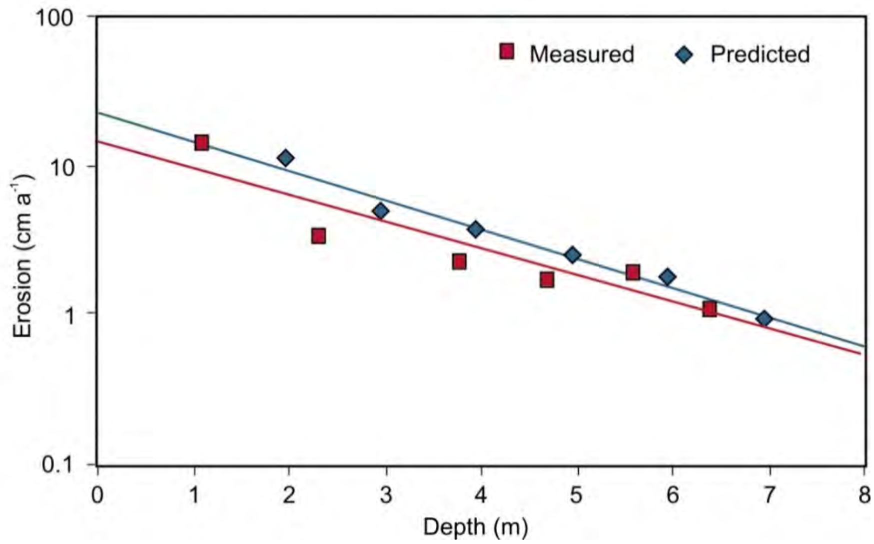


Figure 7: Comparison of measured average annual vertical erosion rates at Grimsby, Lake Ontario with rates predicted from equation 1 and measured average annual bluff recession rate of 1.1 m/y. (Davidson-Arnott, 2010, Fig. 13.16)

Underwater erosion of the till surface results from currents associated with wave orbital motion and also from turbulence due to wave breaking in shallow water (Skafel and Bishop, 1994; Skafel, 1995; Davidson-Arnott and Ollerhead, 1995). Locally, erosion is also enhanced by turbulence around individual rocks and boulders on the surface or embedded in the till. As is the case for erosion of the bluff toe, underwater erosion by waves is also greatly aided by the presence of sand and gravel on the nearshore profile which results in abrasion of the till surface. This has been demonstrated in laboratory experiments (Skafel and Bishop, 1994; Skafel, 1995) and in field experiments (Davidson-Arnott and Ollerhead, 1995; Davidson-Arnott and Langham, 2000). These and other studies show that a layer of sand and gravel 3-5 cm thick is sufficient to produce a very large increase in the rate of erosion compared to water alone (Figure 8).

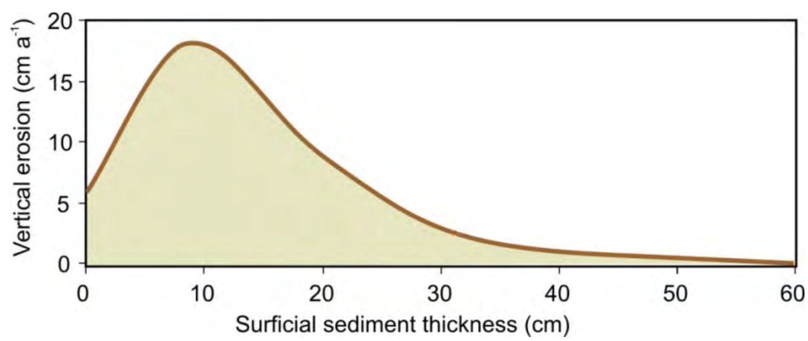


Figure 8: Hypothetical relationship between average surficial sediment cover on the cohesive profile versus average rate of downcutting. The scales are intended to suggest the order of magnitude relationship for a point in shallow water. Note that some erosion will continue underwater in places even with quite thick sediment cover because the sediment is not distributed uniformly (Davidson-Arnott, 2010 – Figure 13.19).

However, a thick covering of sand and gravel or the development of a lag of cobbles and boulders acts to protect the underlying till surface so that the rate of erosion is reduced as the thickness increases (Figure 9).

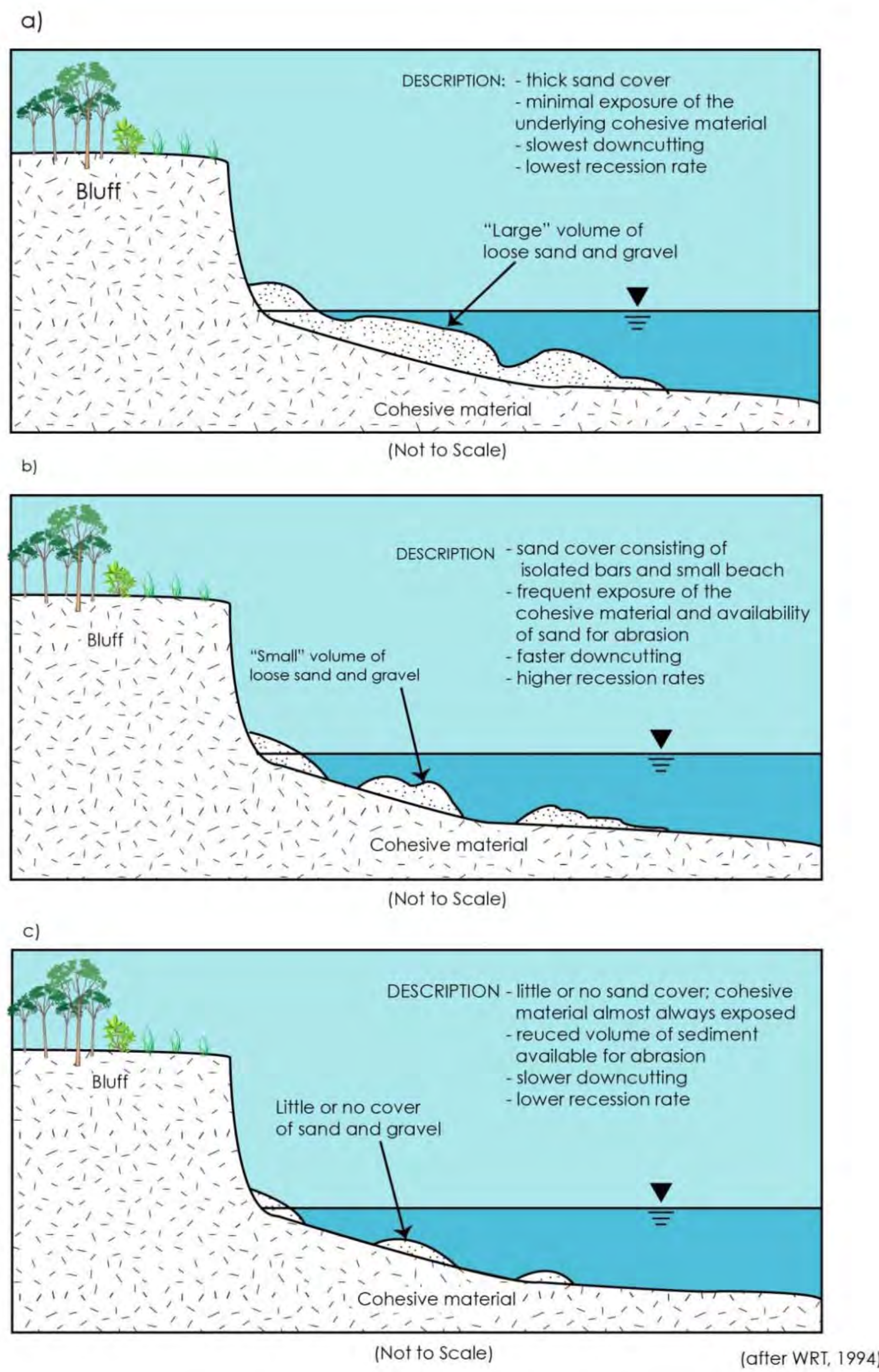


Figure 9: Schematic showing the effects of varying sand and gravel cover on exposure of till underwater (from MNR Technical Guide-Part 1: Figure A1.2.4 Cohesive Shores and the Role of Sand/Gravel Cover. Page A1-2-6 (2001)).

While a layer on the order of 30-50 cm may be sufficient to prevent erosion during an individual storm, sand and gravel tends to move seasonally and over a period of years, e.g. with the movement of bars and decadal fluctuations in lake level. As a result, the till surface may be exposed and eroded at different locations and different times (Davidson-Arnott and Ollerhead, 1995; Davidson-Arnott and Langham, 2000; Schrottke et al., 2005 - See Figure 9).

Similar to erosion on the bluff face and bluff toe, underwater erosion is also aided by weathering and a reduction in the strength of the till. This occurs due to expansion of the till surface as the overlying material is eroded and is aided by pressure fluctuations associated with the passage of waves which pump water into a thin layer near the surface and gradually increase the size of the pore spaces, thus reducing the frictional strength (Davidson-Arnott and Askin, 1980; Davidson-Arnott and Langham, 2000). The presence of this layer is readily seen on the till surface underwater (Figure 10) and expansion of the surface has been detected through repeated measurements at underwater erosion stations (Davidson-Arnott and Langham, 2000).

Figure 10: Underwater photo of till surface showing removal of a thin surface layer of weathered silt and clay by the finger of a wetsuit glove.

The effect can also be measured in cores of the till taken underwater. Figure 11a shows water content and shear strength measured every 2 cm into a core taken 220 m offshore in 4 m water depth. As the water content increases the grains are forced further apart and this reduces the shear strength from about 50 kiloPascals (kPa) below 20 cm to less than 20 kPa near the surface. Figure 11b and 11c show the same core and two others taken in water depths of 1.5 and 3 m. Because erosion of the till is more frequent close to shore the softened layer is only 10-15 cm thick. In the deeper water erosion takes place only during large storms and so the depth of the weathered layer is up to 20 cm.

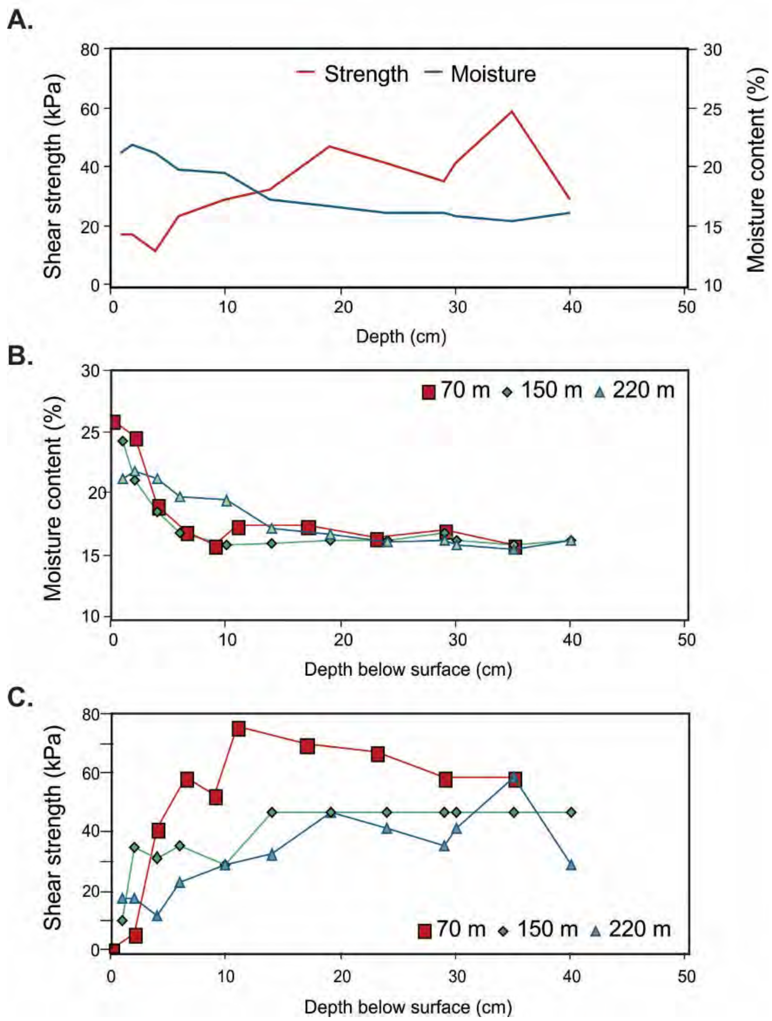


Figure 11: Variations in moisture content and shear strength within 5 cm diameter cores taken underwater in Lake Ontario at St. Catharines: a) variations in moisture content and shear strength in a single core taken 220 m offshore in a water depth of 4 m. Note that increasing moisture content towards the surface is associated with decreasing shear strength; b) variations in moisture content and c) shear strength in cores taken 70, 150 and 220 m offshore (water depth of 1.3, 3 and 4 metres). The softened layer is about 10 cm thick in shallow water, 15 cm at a depth of 3 m and up to 20 cm in water deeper than 4 m. (After Davidson-Arnott and Langham, 2000).

The key factor here is that the reduced till strength permits erosion to occur more rapidly and into deeper water where wave action only reaches the bed during large storms. It is also notable that underwater erosion associated with an individual wave event is generally small – millimetres to a few centimetres at most (Davidson-Arnott 1986; Davidson-Arnott and Ollerhead, 1995; Davidson-Arnott and Langham, 2000) but it occurs quite frequently, especially in water depths <4m where significant wave action is experienced many times in a year. In addition, while toe erosion of the bluff tends to be associated primarily with periods of high lake level, underwater erosion occurs at all lake levels.

While vertical erosion of intertidal rock platforms has been carried out in numerous locations world-wide (e.g., Stephenson et al., 2012), there have been relatively few short-term measurements underwater on either rock coasts or cohesive coasts. Measurements were initiated in 1980 near

Grimsby on Lake Ontario (Davidson-Arnott and Askin, 1980; Davidson-Arnott, 1986) using a modified form of erosion meter used to measure vertical erosion on rock platforms (Askin and Davidson-Arnott, 1980 – see Figure 12). In that year some measurements were made by Coakley et al. (1986) at a nearby site. Subsequently, measurements were carried out near St. Catharines (Davidson-Arnott and Ollerhead, 1995; Davidson-Arnott and Langham, 2000) and also at two sites on Lake Huron (Davidson-Arnott et al., 1999).

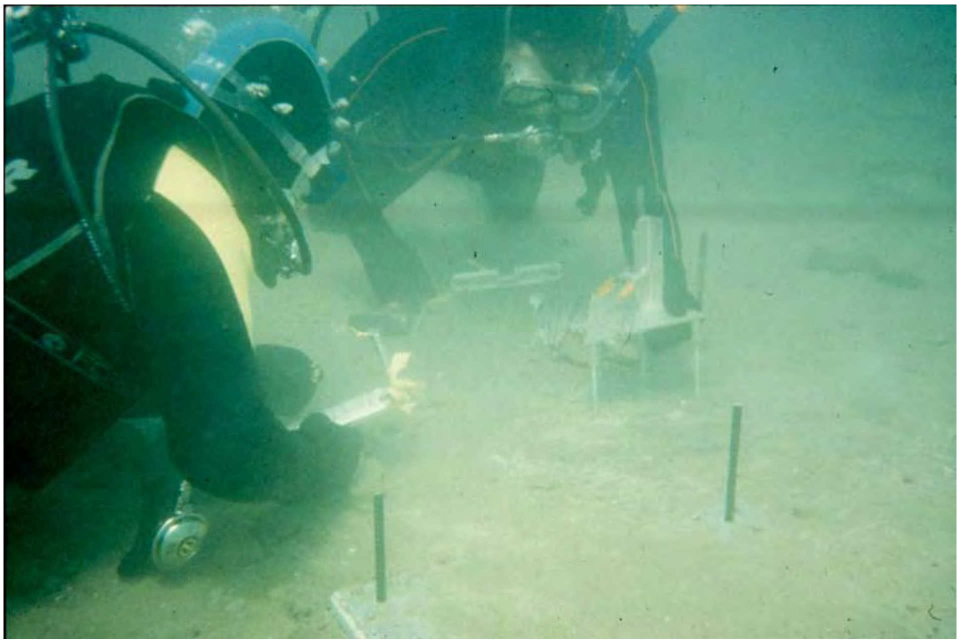


Figure 12: Measuring underwater erosion of in Lake Ontario at St. Catharines. The erosion station (centre right) consists of 3 metal pins hammered into the till and levelled. The MEM is positioned on the pins for each measurement and the distance to the bed in the middle of each side is measured using a 'foot' which slides in a tube and the distance to the till surface is measured against a vertical scale. The large pins in the foreground are holding in place one of the plates used to protect the surface from erosion and wave pressure fluctuations in order to assess the role of till softening over time (after Davidson-Arnott and Langham, 2000).

Annual measurements were made within the ABCA shoreline at a site near Lane O'Pines in 1993-94 and 1994-95. A total of 14 stations were put in in 1993 and measurements were made at 12 in 1994 and 4 in 1995. Some stations in shallow water were lost or damaged as a result of ice action or could not be relocated because of the movement of sand and cobbles. The results for this site are shown in Figure 13.

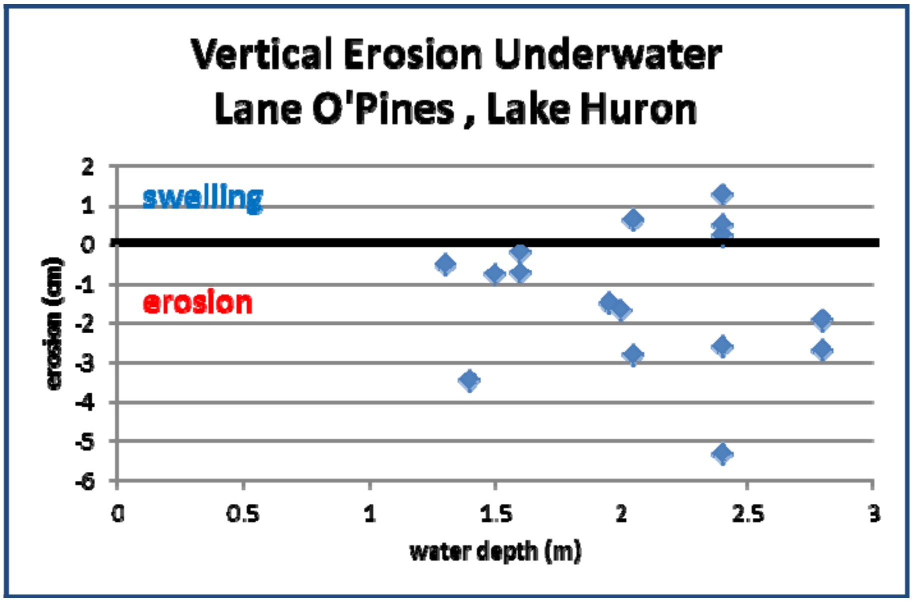


Figure 13: Annual measurements of vertical erosion of till near Lane O'Pines in 1993-4 and 1994-5. The erosion stations are located between 40 and 200 m offshore. Each measurement is an average of three points at that station. Erosion ranged from 0.2 cm/y to a maximum of 5.3 cm/y. Note that positive measurements were obtained on four occasions indicating expansion of the till surface.

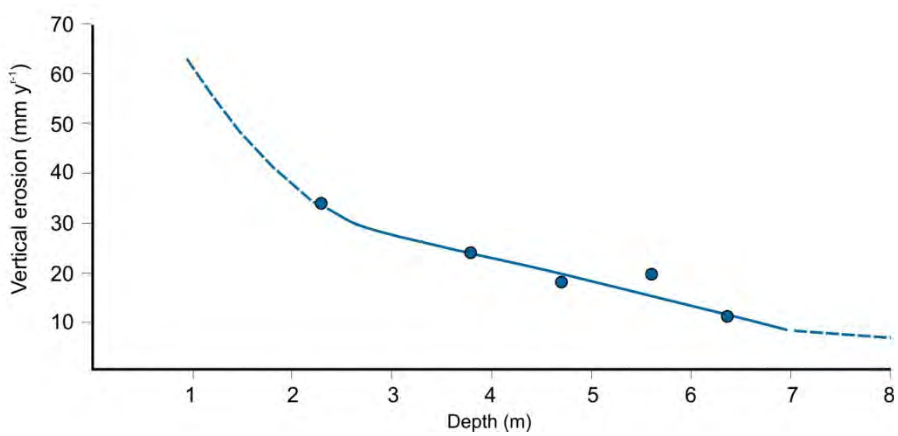


Figure 14: Weighted average annual measurements of vertical erosion at Grimsby, Lake Ontario based on measurements along two lines 1980-1984 (after Davidson-Arnott, 1986, 2010). The dashed lines indicate trends based on a small number of measurements.

Erosion of the profile tends to occur more frequently in shallow water and on the beach, and the rate decreases with depth offshore (Figure 14). The effect of this is to produce a typical concave profile producing a typical concave profile such as those for St. Catharines (Lake Ontario) and Horizon View (Lake Huron) - see Figure 15a. However, where the sediment cover is quite thick, erosion in shallow water proceeds more slowly and the profile flattens out more quickly, as it does for the Lane O'Pines profile (Figure 15a, b).

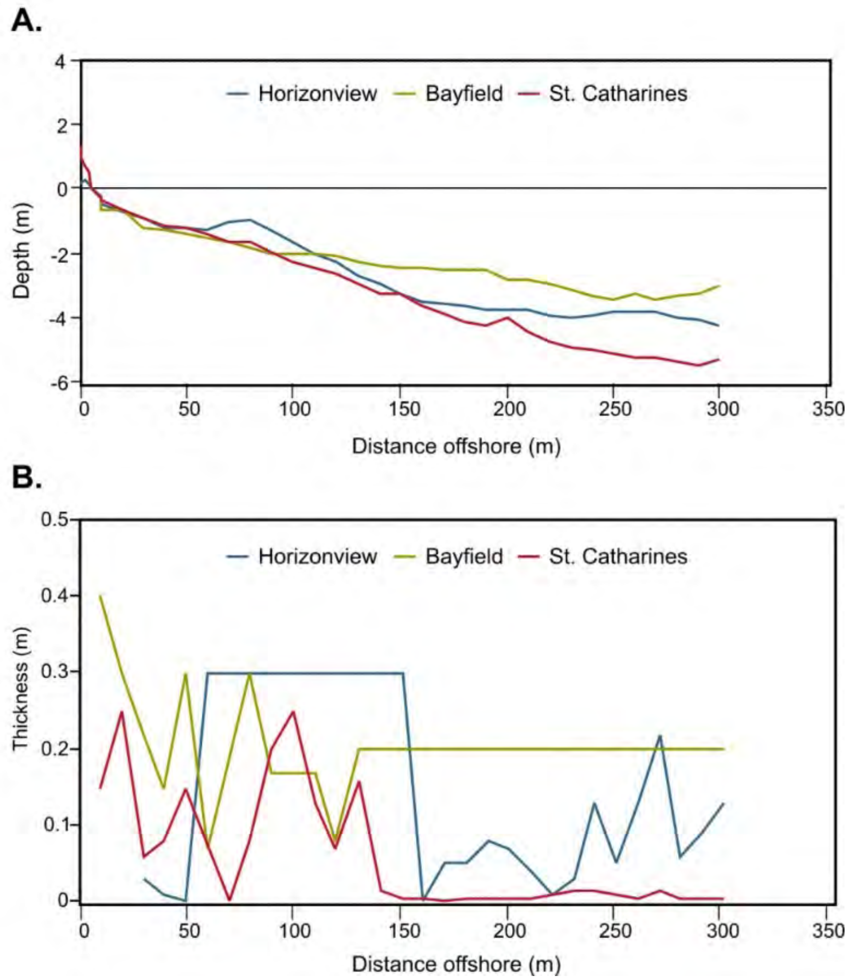


Figure 15: Nearshore profiles from three locations with cohesive bluff shorelines on the Great Lakes: a) nearshore profiles for Horizon View (Lake Huron south of Point Clark) Bayfield (Lake Huron north of Bayfield) and St. Catharines (west of Port Dalhousie); b) thickness of surficial sediment overlying the till for each of the profiles shown in (a), (from Davidson-Arnott, 2010, Fig. 13.22).

Modelling of the littoral sediment transport pattern and sediment supply on Lake Huron at Stoney Creek (Amin and Davidson-Arnott, 1997) and on the north shore of Lake Huron from Point Clark to Goderich (Lawrence and Davidson-Arnott, 1997) has shown that there is generally a strong correlation between modelled pattern of supply and longshore sediment transport rate, and factors such as beach width and bluff recession rate. Thus, for example, results for Lake Huron show that the area with the highest recession rate at Horizon View coincides with relatively little sand supply from updrift, a narrow beach and increasing wave energy (Figure 16). At the south end of the section near Wrights Point there is little erosion despite high wave energy because of the large sand supply and wider beaches (Figure 16).

The rate of underwater erosion, and hence the rate of bluff recession, will decrease with increasing sediment cover across the nearshore profile. In the littoral cell from Goderich to Grand Bend, including the ABCA cohesive shoreline, sand is transported southward under the influence of the dominant NW waves. It is evident from an examination of the shoreline within the ABCA jurisdiction that the extent of beach and nearshore sediment cover varies spatially, and in some area also temporally, so that the degree of protection provided is not uniform. It has been demonstrated this is a function of both the

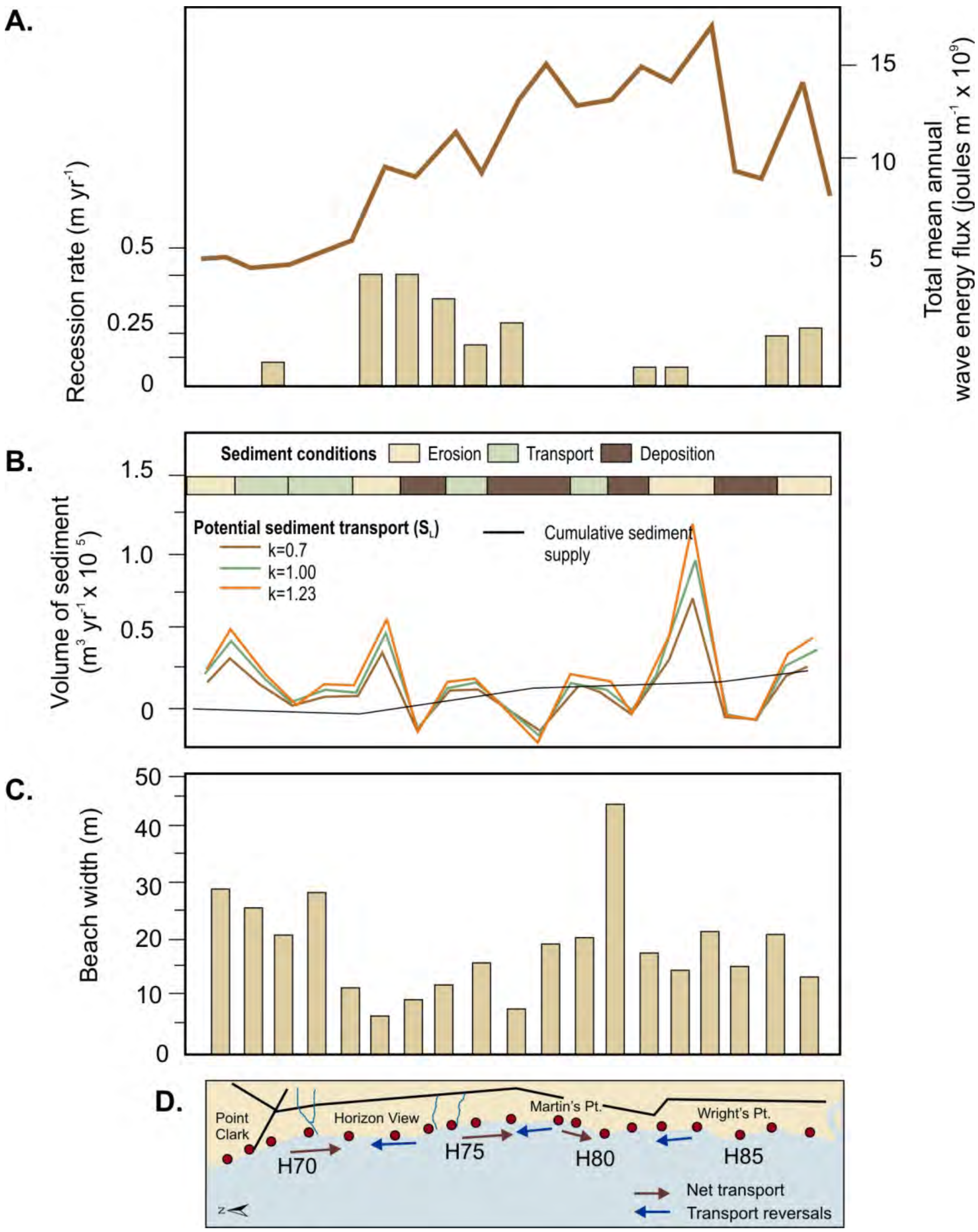


Figure 16: Comparison of modelling of littoral sediment transport with geomorphic indicators for a section of the Lake Huron shoreline: (a) plot of the spatial distribution of the mean annual bluff recession rate versus the mean annual total wave energy flux predicted from the model; (b) the alongshore distribution of potential sediment transport based on modelling and the available littoral sediment supply based on the bluff recession rate and bluff composition. Zones of potential erosion, transport and deposition are based on the alongshore transport gradient; (c) alongshore variations in beach width measured on one day; (d) map of the coastline between Pt. Clark and Goderich. The dots mark locations of calculations for model values and the numbered stations are sites of long-term bluff

recession monitoring (Lawrence and Davidson-Arnott, 1997; Davidson-Arnott, 2010 Figure 7.23).

sediment supply from bluff and nearshore erosion updrift, and the pattern and rate of longshore sand transport which in turn reflects the local nearshore bathymetry and shoreline orientation.

Similar controls on sand supply and beach width likely influence the patterns of bluff recession within the ABCA shoreline. While more sophisticated models such as Mike 21 and Delft3D may improve the modelling process, the results indicate just how important ongoing sand supply from updrift is as a control on local bluff recession rates. In particular, a decrease in sand supply to much of the cohesive bluff shore of the ABCA would likely lead to a significant increase in the measured rates of bluff recession.

Effects of lake level fluctuations

Fluctuations in the level of Lake Huron seasonally, and especially on a decadal scale, influence the pattern of vertical erosion underwater as well as horizontal bluff recession (Davidson-Arnott, 1990). Seasonal and longer term fluctuations combined with storm events lead to onshore and offshore migration of sediment in the nearshore and thus affect the thickness of the sand cover overlying the till on a temporal basis. As is depicted in Figure 6, periods of low lake level produce an increase in the rate of erosion at any point on the nearshore profile because with the shallower water depth the bed is exposed to greater wave energy and sediment transport across the till surface. In particular the zone of intense wave breaking during major storms, which produces the greatest scour of the bed (Skafel and Bishop, 1995), moves offshore. During high lake levels this zone is located further landward closer to the shoreline and erosion tends to be focussed at the beach and in some cases at the bluff toe. In contrast, periods of low lake level, such as experienced recently from about 2000 to 2014, are associated with wider beaches in most areas and in places the build-up of small sand dunes. Sections of shoreline where the long-term recession rate is quite small may be protected from toe erosion for periods of years to a decade or more. However, when there is a succeeding rise in lake level wave attack at the bluff toe is enhanced by the deepening of the nearshore profile during the low lake level phase which allows large waves to break closer to the beach and the bluff toe. Over a period of 100 years these variations in bluff toe erosion tend to even out to a long-term average, and indeed, on Lake Ontario where long-term lake level fluctuations have been greatly reduced because of the regulation of outflow from the lake since the early 1950s bluff recession takes place much more evenly.

Models of cohesive coast erosion processes (Nairn and Southgate, 1993; Trenhaile, 2009) have provided an appraisal of the assumptions of the equilibrium between toe recession and lowering of the nearshore profile. They have also been utilised to assess the effects of changing wave climate and water level as part of several IJC studies, including the most recent Upper Great Lakes Study. Modelling of the effect of lake level fluctuations on bluff recession rates has shown that over a period of about 100 years the average recession rate will be the same as for a regulated lake (Nairn, R.B. and Southgate, H.N. 1993; Geomorphic Solutions, 2010b).

Implications for shore protection structures

Ongoing erosion of the nearshore profile poses a problem for the longevity of shore protection structures that are placed at the bluff toe, beach and into the water. While the till can be sufficiently strong to provide a firm foundation for anchoring structures such as revetments, vertical steel sheet pile walls or groynes, the structure itself is subject to increasing wave energy over time because of the increased water depth in front of the structure, in the case of seawalls and revetments, or at the lakeward end of groynes. The lifespan of the structure can be increased by making it more robust, e.g., by using materials such as armourstone, but the trade-off is that these structures are a lot more expensive to construct. Erosion rates in front of shore parallel structures will be accelerated by reflection from the structure, particularly during high lake level phases and undercutting of the foundations ultimately leads to collapse of all or part of the structure.

Potential effects of climate change on erosion of the cohesive bluff coast within the ABCA shoreline

The reduction in the extent and duration of winter ice cover as a result of climate change will bring about an increase in the number of intense storms with large waves that will affect the shoreline of southern Lake Huron (see the associated discussion paper on Climate Change accompanying the ABCA Shoreline Management Plan update). This occurs primarily because some storms which did not generate waves due to the presence of ice will now be able to do so and thus the total number of storms in a year that generate large waves will increase. The increased level of wave energy will likely lead to increased underwater erosion and thus, ultimately, to an increase in the rate of bluff recession. While this will generate an increase in the supply of sand and gravel, it is likely that the rate at which this is transported alongshore will increase and thus there will be no accompanying increase in the level of protection provided.

References

Amin, S. M. N. and Davidson-Arnott, R.G.D. 1995. Toe erosion of glacial till bluffs, Lake Erie south shore. Canadian Journal of Earth Sciences, 32, 829-837.

Amin, S.M.N. and Davidson-Arnott, R.G.D., 1997. A statistical analysis of the controls on rates of bluff recession, Lake Ontario. Journal of Coastal Research, 13, 1093-1101.

Askin, R.W. and Davidson-Arnott, R.G.D., 1981. Micro erosion meter modified for use underwater. Marine Geology, 40, M45-M48.

Blanco-Chao R, Perez Alberti A, Trenhaile AS, Costa Casais A, Valcarcel-Diaz M. 2007. Shore platform abrasion in a para-periglacial environment, Galicia, northwestern Spain. Geomorphology, 83,136–151. DOI: 10.1006/j.geomorph.2006.06.028

Brew, D., 2004. Understanding and Predicting Beach Morphological Change Processes Associated with the Erosion of Cohesive Foreshores Scoping Report. Technical Report FD1915DEFRA/Environment Agency, London, 73pp.

Brown, E.A., Wu, C.H., Mickelson, D.M., and Edil, T.B. 2005. Factors controlling rates of bluff recession at two sites on Lake Michigan. Journal of Great Lakes Research, 31, 306-321.

Buckler, W.R. and Winters, H.A. 1983. Lake Michigan bluff recession. Annals of the Association of American Geographers, 73, 89-110.

Coakley, J., Rukavina,N.A. and Zeman, A. J ., 1986. Wave-induced subaqueous erosion of cohesive tills: preliminary resulls. In, Proceedings of the Symposium on Cohesive Shores.National Research Council, Canada. pp. 120-136.

Carter, C.H. and Guy, D.E. Jr. 1988. Coastal erosion: processes, timing and magnitudes at the bluff toe. Marine Geology, 84, 1-17.

Davidson-Arnott, R.G.D. 1986. Rates of erosion of till in the nearshore zone. Earth Surface Processes and Landforms, 11, 53-58.

Davidson-Arnott, RG.D. 1990. The effects of water level fluctuations on coastal erosion in the Great Lakes. Ontario Geographer, 10, 12–25.

Davidson-Arnott, R.G.D., 2010. Introduction to Coastal Processes and Geomorphology. Cambridge University Press, Cambridge, England. 442pp.

Davidson-Arnott, R.G.D. and Askin, R.W.1980. Factors controlling erosion of the nearshore profile in overconsolidated till, Grimsby, Lake Ontario. Proceedings Canadian Coastal Conference, National Research Council of Canada, Ottawa, Canada, pp. 185-199.

Davidson-Arnott, R.G.D. and Amin, S.M.N. 1985. An approach to the problem of coastal erosion in Quaternary sediments. Applied Geography, 5, 99-116.

Davidson-Arnott, R.G.D. and Ollerhead, Jocelyn 1995. Nearshore erosion on a cohesive shoreline. Marine Geology, 122, 349-365.

Davidson-Arnott, R.G.D. and Langham, D.R.J. 2000. The effects of softening on nearshore erosion on a cohesive shoreline. Marine Geology, 166, 145-162.

Davidson-Arnott, R.G.D., van Proosdij, D., Ollerhead, Jocelyn, and Langham, D., 1999. Rates of erosion of till in the nearshore zone on Lakes Huron and Ontario. Proceedings Canadian Coastal Conference, CCSEA, 627-636.

Edil, T.B. and Vallejo, L.E. 1980. Mechanisms of coastal landslides and the influence of slope parameters. Engineering Geology, 16, 83-96.

Gelinas, P.J. and Quigley, R.M. 1973. The influence of geology on erosion rates along the north shore of Lake Erie. Proceedings 16th Conference on Great Lakes Research, 421-430.

Geomorphic Solutions, 2010a. Introduction to Erosional Cohesive Bluff Assessment. Report prepared for the International Joint Commission Upper Great Lakes Study, 17 pp.

Geomorphic Solutions, 2010b. Cohesive Shoreline Erosion Modelling Results. Report prepared for the International Joint Commission, Upper Great lakes Study, 55 pp. + 3 Appendices.

Hampton, M.A. and Griggs, G.B. (editors), *Formation, Evolution and Stability of coastal Cliffs-Status and Trends*. United States Geological Survey, Professional Paper 1693, 53-64.

Healy, T.R. and Wefer, G. 1980. The efficacy of submarine erosion versus cliff retreat as a supplier of marine sediment in the Kieler Bucht, Western Baltic. Meyniana, 32, 89-96.

Hutchinson, J.N. 1986. Cliffs and shores in cohesive materials: geotechnical and engineering aspects. Proceedings Symposium on Cohesive Shores, National Research Council of Canada, Ottawa, Canada, 1-44.

Joyal, Gabriel, Patrick Lajeunesse, Morissette, Antoine and Bernatchez, Pascal, 2016. Influence of lithostratigraphy on the retreat of an unconsolidated sedimentary coastal cliff (St. Lawrence estuary, eastern Canada). Earth Surface Processes and Landforms, 41, 1055–1072

Kamphuis, J.W. 1987. Recession rate of glacial till bluffs. Journal of Waterway, Port, Coastal and Ocean Engineering, 113, 60-73.

Kamphuis, J.W. 1990. Influence of sand or gravel on the erosion of cohesive sediment. Journal of Hydraulic Research, 28, 43-53.

Lawrence, P.L. and Davidson-Arnott, R.G.D., 1997. Alongshore wave energy and sediment transport on south-eastern Lake Huron, Ontario, Canada. Journal of Coastal Research, 13, 1004-1015.

Nairn, R.B. and Southgate, H.N. 1993. Deterministic profile modelling of nearshore processes. Part 2. Sediment transport and beach profile development. Coastal Engineering, 19, 57 – 96.

Nairn, R.B., Pinchin, B.M., Philpott, K.L., 1986. Cohesive profile development model. In: Skafel, M.G. (Ed.), Proceedings of the Symposium on Cohesive Shores, National Research Council of Canada (ACROSES), Ottawa, pp. 246-261.

Ontario Ministry of Natural Resources. (2001) . Great Lakes — St. Lawrence River System and Large Inland Lakes Technical Guides for flooding, erosion and dynamic beaches in support of Natural Hazards Policies 3.1 of the Provincial Policy Statement (1997) of the Planning Act. Published by Watershed Science Centre, Trent University Peterborough, Ontario, Canada Copyright © 2001 The Queen's Printer for Ontario.

Philpott, K.L. 1986. Coastal engineering aspects of the Port Burwell shore erosion damage litigation. Proceedings Symposium on Cohesive Shores, National Research Council of Canada, Ottawa, Canada, 309–338.

Quigley, R.M., Gelinas, P.J., Bou, W.T. and Packer, R.W. 1977. Cyclic erosion-instability relationships: Lake Erie north shore bluffs. Canadian Geotechnical Journal, 14, 301-323.

Schrottke, K., Schwarzer, K. and Fröhle, P., 2006. Mobility and transport directions of residual sediments on abrasion platforms in front of active cliffs (southwestern Baltic Sea). Journal of Coastal Research, SI 39, 459-464.

Skafel, M.G. 1995. Laboratory measurements of nearshore velocities and erosion of cohesive sediment (till) shorelines. Coastal Engineering, 24, 343–349.

Skafel, M.G., Bishop, C.T. 1994. Flume experiments on the erosion of till shores by waves. Coastal Engineering, 23, 329–348.

Sunamura, T. 1977. A relationship between wave-induced cliff erosion and erosive force of waves. Journal of Geology, 85, 613-618.

Sunamura, T. 1983. Processes of sea cliff and platform erosion. In, Komar, P.D. (editor), Handbook of Coastal Processes and Erosion. CRC Press, Boca Raton, Florida, 233-265.

Trenhaile, A.S. 2009. Modeling the erosion of cohesive clay coasts. Coastal Engineering, 56, 59-72.

Zenkovitch, V.P., 1967. *Processes of Coastal Development*, Oliver and Boyd, Edinburgh, 738pp.

Appendix G: Relevant Sections of PPS (2014)

The following sections of the Protecting Public Health and Safety apply to the shoreline of Lake Huron. From PPS Section 3.0 Protecting Public Health and Safety.

"Ontario's long-term prosperity, environmental health and social well-being depend on reducing the potential for public cost or risk to Ontario's residents from natural or human- made hazards. Development shall be directed away from areas of natural or human-made hazards where there is an unacceptable risk to public health or safety or of property damage, and not create new or aggravate existing hazards.

3.1 **Natural Hazards**

3.1.1 Development shall generally be directed to areas outside of:

a) *hazardous lands* adjacent to the shorelines of the *Great Lakes - St. Lawrence River System* and *large inland lakes* which are impacted by *flooding hazards*, *erosion hazards* and/or *dynamic beach hazards*;

c) *hazardous sites.*

3.1.2 *Development* and *site alteration* shall not be permitted within:

a) the *dynamic beach hazard;*

b) areas that would be rendered inaccessible to people and vehicles during times of *flooding hazards*, *erosion hazards* and/or *dynamic beach hazards*, unless it has been demonstrated that the site has safe access appropriate for the nature of the *development* and the natural hazard; and

3.1.3 Planning authorities shall consider the potential impacts of climate change that may increase the risk associated with natural hazards.

3.1.5 *Development* shall not be permitted to locate in *hazardous lands* and *hazardous sites* where the use is:

a) an *institutional use* including hospitals, long-term care homes, retirement homes, pre-schools, school nurseries, day cares and schools;

b) an *essential emergency service* such as that provided by fire, police and ambulance stations and electrical substations; or

c) uses associated with the disposal, manufacture, treatment or storage of *hazardous substances*.

3.1.7 Further to policy 3.1.6, and except as prohibited in policies 3.1.2 and 3.1.5, *development* and *site alteration* may be permitted in those portions of *hazardous lands* and *hazardous sites* where the effects and risk to public safety are minor, could be mitigated in accordance with provincial standards, and where all of the following are demonstrated and achieved:

g) *development* and *site alteration* is carried out in accordance with *floodproofing standards*, *protection works standards*, and *access standards*;

h) vehicles and people have a way of safely entering and exiting the area during times of flooding, erosion and other emergencies;

i) new hazards are not created and existing hazards are not aggravated; and

j) no adverse environmental impacts will result."

Appendix H: MNRF Technical Guide CD Summary

TABLE OF CONTENTS

CLICK ON THE TITLE – Acrobat Reader will automatically jump to that page.
RETURN TO THIS PAGE to jump to other sections of the CD document collection.
"Acrobat Reader" can do word searches within that particular document (Command/Alt + F, next word Command/Alt + G)
"Acrobat Reader with Search" can locate words throughout the entire CD PDF collection.

To facilitate user-printouts, all pages have been oriented vertically. To view a page horizontally in Acrobat Reader with Search, go to view menu to use the "rotate" commands, or use the rotate icons located in the Acrobat menu bar in the 6th and 7th positions from the top right. Acrobat Reader does not have rotate viewing options available.

DISCLAIMER

The Great Lakes - St. Lawrence River System and large inland lakes technical guides for flooding, erosion and dynamic beaches, and related shoreline databases, contained herein, have been prepared to assist planning authorities address hazardous lands and hazardous sites in accordance with the Natural Hazards Policies 3.1 of the Provincial Policy Statement of the Planning Act.

The said guides and databases are provided by the Ministry without warranty or representation of any kind, express or implied, statutory or otherwise. Responsibility for identification and management of hazardous lands is the planning authorities'.

In no event shall the Ministry of Natural Resources be liable or responsible for any inaccuracy, omission or error which the technical guides and shoreline databases may contain, or for the fitness of the manual for any particular purpose, or for any damage or loss of any kind whatsoever which any party may suffer as a result of the use or reliance upon any statement which the technical guides or shoreline database documents may contain.

Appendix I: Erosion Hazard References

Erosion Hazard References

The Following Appendix Outlines key supporting documentation from MNRF Technical Guide Part 4 (2001) and the MNRF Geotechnical Principles for Stable Slopes (1997) which assists in assessing the Erosion and Slope Stability Hazards to ultimately determine the Level of Study that will be necessary to address adequately the Slope Stability issues on a site.

TABLE 7.4 - Slope Inspection Record

1. FILE NAME / NO.
INSPECTION DATE (DDMMYY):
WEATHER (circle): ○ sunny ○ partly cloudy ○ cloudy
○ calm ○ breeze ○ windy
○ clear ○ fog ○ rain ○ snow
○ cold ○ cool ○ warm ○ hot
estimated air temperature:
INSPECTED BY (name):

2. SITE LOCATION (describe main roads, features)

SKETCH

3. WATERSHED

4. PROPERTY OWNERSHIP (name, address, phone):

LEGAL DESCRIPTION
Lot
Concession
Township
County

CURRENT LAND USE (circle and describe)
○ vacant - field, bush, woods, forest, wilderness, tundra,

○ passive - recreational parks, golf courses, non-habitable structures, buried utilities, swimming pools,

○ active - habitable structures, residential, commercial, industrial, warehousing and storage,

○ infra-structure or public use - stadiums, hospitals, schools, bridges, high voltage power lines, waste management sites,

5. SLOPE DATA
HEIGHT ○ 3 - 6 m ○ 6 - 10 m ○ 10 - 15 m ○ 15 - 20 m
○ 20 - 25 m ○ 25 - 30 m ○ > 30 m
estimated height (m):

INCLINATION AND SHAPE

○ 4:1 or flatter 25 % 14°	○ up to 3:1 33 % 18½°	○ up to 2:1 50 % 26½°
○ up to 1:1 100 % 45°	○ up to ½:1 200 % 63½°	○ steeper than ½:1 > 63½°

6. SLOPE DRAINAGE (describe)
TOP

FACE

BOTTOM

Terraprobe

Source MNRF, Geotechnical Principles for Stable Slopes (1997)

Geotechnical Principles for Stable Slopes
Ontario Ministry of Natural Resources

Page No. 101
November 1997

7. SLOPE SOIL STRATIGRAPHY (describe, positions, thicknesses, types) TOP FACE BOTTOM
8. WATER COURSE FEATURES (circle and describe) SWALE, CHANNEL GULLY STREAM, CREEK, RIVER POND, BAY, LAKE SPRINGS MARSHY GROUND
9. VEGETATION COVER (grasses, weeds, shrubs, saplings, trees) TOP FACE BOTTOM
10. STRUCTURES (buildings, walls, fences, sewers, roads, stairs, decks, towers,) TOP FACE BOTTOM
11. EROSION FEATURES (scour, undercutting, bare areas, piping, rills, gully) TOP FACE BOTTOM
12. SLOPE SLIDE FEATURES (tension cracks, scarps, slumps, bulges, grabens, ridges, bent trees) TOP FACE BOTTOM
13. PLAN SKETCH OF SLOPE
14. PROFILE SKETCH OF SLOPE

Terraprobe

Source MNRF, Geotechnical Principles for Stable Slopes (1997)

Table 4.2 Slope Stability Rating Chart

Site Location:		File No.
Property Owner:		Inspection Date:
Inspected By:		Weather:

			Rating Value circle one
1. SLOPE INCLINATION			
	degrees	horz. : vert.	
a)	less than 18	3:1 or flatter	0
b)	18 to 27	2:1 to 3:1	6
c)	more than 27	steeper than 2:1	16
2. SOIL STRATIGRAPHY			
a)	Shale, Limestone (Bedrock)		0
b)	Sand Gravel		6
c)	Till		9
d)	Clay, Silt		12
e)	Fill		16
3. SEEPAGE FROM SLOPE FACE			
a)	None or Near bottom only		0
b)	Near mid-slope only		6
c)	Near crest only or, From several levels		12
4. SLOPE HEIGHT			
a)	2 m or less		0
b)	2.1 to 5 m		2
c)	5.1 to 10 m		4
d)	more than 10 m		8
5. VEGETATION COVER ON SLOPE FACE			
a)	Well vegetated; heavy shrubs or forested with mature trees		0
b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		4
c)	No vegetation, bare		8
6. TABLELAND DRAINAGE			
a)	Tableland flat, no apparent drainage over slope		0
b)	Minor drainage over slope, no active erosion		2
c)	Drainage over slope, active erosion, gullies		4
7. PREVIOUS LANDSLIDE ACTIVITY			
a)	No		0
b)	Yes		6
			TOTAL

	SLOPE INSTABILITY RATING	RATING VALUES TOTAL	INVESTIGATION REQUIREMENTS
1.	Low potential	< 24	Site Inspection only, confirmation, report letter.
2.	Slight potential	25 - 35	Site Inspection and surveying, preliminary study, detailed report
3.	Moderate potential	> 35	Borehole Investigation, piezometers, lab tests, surveying,detailed report.

Notes:
a) This chart does not apply to rock slopes or to Leda Clay slopes (e.g., Ottawa area)
b) Choose only one from each category by circling rating value; compare total rating value with above requirements.
c) If there is a water body (i.e., stream, creek, river, pond, bay, lake) at the slope toe: the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.
d) Refer to Section 2 for information on identifying soil types.

Source MNRF Technical Guide Part 4 – Table 4.2, Page 4-29

Appendix J: Shoreline Landowner Fact Sheet

Slope instability indicators include displaced posts and fences, poles, monuments, guardrails, broken or displaced retaining walls, and stairs, among other indicators mentioned in this fact sheet. Please read the Recommended Management Practices panel inside.

Ausable Bayfield Conservation Authority (ABCA)

Shoreline Slope Stability Risks and Hazards

Fact Sheet for Property Owners

The Lake Huron shoreline is a spectacular feature. It is enjoyed by many as a place to visit, work, recreate, and live. As a result, much of the shoreline has been developed. Recently, many seasonal residences have evolved into permanent homes. Portions of this shoreline, however are subject to erosion and bluff instability.

This fact sheet has been created to inform shoreline property owners of:

- Indicators of potential bluff instability and associated risks
- Best management practices for bluff stability and shoreline areas; and
- Sources of additional information.

AUSABLE BAYFIELD CONSERVATION – CREATING AWARENESS | TAKING ACTION

Terraprobe Inc. – Consulting Geotechnical & Environmental Engineering, Construction Materials, Inspection & Testing

Shoreline Slope Stability Risks and Hazards - Fact Sheet for Property Owners • Page 1

About the Lake Huron Shoreline

Much of the Lake Huron shoreline, within the Ausable Bayfield Conservation Authority (ABCA) jurisdiction, is bluff. The bluff material is made of silt, clay, sand and small rock and was first deposited by glaciers. This is known as a cohesive shoreline. Erosion of this material by Lake Huron has created the tall bluffs.

These shoreline bluffs have been eroding for thousands of years and continue to be subject to wave action at their toe or base. This leads to cycles of erosion and slope instability. This, in turn, results in recession or erosion at the top of the slope. The wave action undercuts and locally over-steepens the slope toe.

This over-steepening of the slope results in slumping which works up to the slope crest. This slumping is a natural phenomenon which helps flatten the slope. The slumping eventually achieves a stable angle for vegetation to establish – provided that the toe erosion is stopped and addressed. Unfortunately, addressing toe erosion may not be feasible on some cohesive shores. This is due to continuous underwater erosion which can take place offshore.

(The term cohesive shoreline is used to describe coasts developed in relatively weak sediments which include some silt and clay to provide the cohesion. Coastal erosion results in the development of cliffs which are called cohesive bluffs to distinguish them from the traditional cliffs formed in hard bedrock.)

Page 2 • Shoreline Slope Stability Risks and Hazards - Fact Sheet for Property Owners

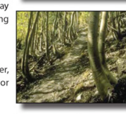
Typical Signs of Slope Instability

*There may be **some or no** signs of slope instability at all prior to a slope slide, depending on site-specific conditions. However, here are typical slope instability signs:*

Bare slope areas (no vegetation)

- Lack or loss of vegetation is a typical sign of over-steepened slope. Vegetation establishment is relatively difficult on steep slopes (generally steeper than 2 horizontal to 1 vertical).
- A recent formation of bare area or loss of vegetation on a slope may indicate a slump, soil erosion or formation of an over-steepening zone.

Bent Trees



- Bent and bowed trees may be due to slope soil creep, however, it may also be due to initial root development and twisting or bowing growth in response to reaching for sunlight.

Tension cracks

- A tension crack formation close to the top of slope may indicate a pending slope failure.
- A tension crack is a void that generally runs parallel to the slope face. It can significantly affect the future stability of the slope because a crack filled with water reduces the stability due to the hydrostatic pressure.
- Ice formation within the crack during sub-zero temperature expands and loosens the slope soil in the vicinity.

Irregular Slope Surfaces, Slumps, Scarps, Bumps, Bulges

- A presence of irregular slope surfaces such as slumps, scarps, bumps, bulges, etc. generally indicates a soil movement.
- Slumps and scarps result in an over-steepened (even near vertical) and bare zone at the 'head' or 'crown' where the sliding mass has separated from the slope.
- A slump or slide may also result in tension cracks above the slide.

Other Indicators

Other slope instability indicators include:

- Displaced posts/fences, poles, monuments, guardrails, broken/displaced retaining walls, and stairs.

Shoreline Slope Stability Risks and Hazards - Fact Sheet for Property Owners • Page 3

Recommended Management Practices

DOs and DON'Ts along the Shoreline

Here are recommended management practices for properties located along the shoreline bluff:

Do:

- Any observation of severe slope instability should immediately be brought to the attention of the local municipality and conservation authority. A safety fence should be installed and maintained near the slope crest in the areas of slope failures, over-steepened and near vertical scarps to keep occupants/people away until the condition has been assessed by a qualified engineer.
- Property use should be conducted in a manner which does not result in surface erosion of the slope. In particular, site grading and drainage should prevent direct concentrated or channelized surface runoff from flowing directly over the slope. Water drainage from down-spouts, sumps, swimming pools, road drainage, and the like, should not be permitted to flow over the slope. Minor sheet flow may be acceptable. If water is collected at the slope crest, it should be safely discharged to the bottom of the slope by suitable piping.
- Consult with ABCA prior to removing vegetation on the slope.
- Maintain the lake bank in a natural state with native plants and vegetation.
- Maintain tiled or piped drainage systems in proper working condition to help prevent surface erosion and/or seeps on the lake bank.
- Monitor the condition of the bank regularly for signs of erosion and instability.
- Leave root systems intact in circumstances where tree removal is necessary.
- Undertake maintenance activities by hand where possible and avoid disruption of the lake bank with machinery or heavier equipment.
- All approvals and permits must be secured from ABCA prior to any site alteration.

Don't:

- In order to promote vegetation growth on the slope face, yard and other waste must not be discarded over the slope.
- The configuration of the slope should not be altered without prior consultation with a professional geotechnical engineer and approval from the local conservation authority.
- Do not remove trees unless removal is warranted and approved by authorities.
- On cohesive shores, the long-term stabilization of a bluff/slope with shoreline protection works, may not be practical due to erosion occurring underwater offshore. The ABCA, a professional geotechnical engineer, and a qualified professional coastal engineer should be consulted to determine the site-specific issues for the feasibility of any proposed coastal protection works.

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Erosion Hazard Limit and New Development

New developments are generally directed to be outside of the Erosion Hazard Limit to avoid the risks associated with slope instability and erosion hazards.

The Erosion Hazard Limit is established based on Stable Slope Allowance, Average Annual Recession, and Erosion Allowance as described below:

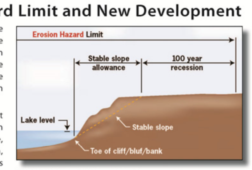

IMAGE SOURCE: Ontario Ministry of Natural Resources and Forestry

1. **Stable Slope Allowance (Stable Slope Inclination Setback)** is a horizontal allowance measured landward from the toe of the shoreline cliff, bluff, or bank. It is:

a) Dependent on slope soil types, soil strengths, and groundwater conditions

b) Assumed to be three times the height of cliff/bluff in absence of site-specific study, or, is determined by a detailed site investigation (boreholes) and analysis (typically minimum Factor of Safety of 1.5 required)

2. **Average Annual Recession**

The average annual recession rate is an average rate of erosion of the shoreline per year for a site where there is at least 35 years of reliable recession information available.

3. **Erosion Allowance**

Where there is no reliable recession information, the Province of Ontario suggests a setback distance to allow for 30-metre erosion allowance along the Great Lakes.

NOTE: The Ausable Bayfield Conservation Authority has calculated the Erosion Hazard Limit for areas along the Lake Huron Shoreline within the ABCA jurisdiction and documented this in its Shoreline Management Plan (SMP). Contact ABCA to obtain further information for your area.

Access Allowance:

In addition, there may be a requirement for an access allowance to allow for safe access around structures during initial construction and long-term maintenance of shoreline slope, property and structures. Typically 6 metres is required.

Shoreline Slope Stability Risks and Hazards - Fact Sheet for Property Owners • Page 5

Notes:

- **1.** This fact sheet and the information included in it pertain to slope stability considerations. Additional setbacks and considerations may be applicable for the determination of shoreline hazards, risks, and erosion hazard limit.
- **2.** The information provided in this fact sheet is for general information purposes only and is not intended to preclude and/or replace the requirement of a property-specific slope stability and coastal investigation/assessment designed to adequately assess potential risks to the property, structures and the occupants.

Terms:

Cohesive shorelines

- The term cohesive shoreline is used to describe coasts developed in relatively weak sediments which include some silt and clay (to provide the cohesion). Coastal erosion results in the development of cliffs which are called cohesive bluffs to distinguish them from the traditional cliffs formed in hard bedrock.

Recession

- Long-term recession of the shoreline is a permanent reduction of the shoreline. Beach erosion may take place and be followed by accretion. Shoreline recession, on the other hand, is a permanent change or impact.

References:

- Geotechnical Principles for Stable Slopes: Terraprobe Limited
- Slope Stability & Erosion Risks – A Regulatory Perspective: B. Singh, M.A.Sc., P. Eng.
- MNRF Guide – Understanding Natural Hazards, Great Lakes - St. Lawrence River System and large inland lakes, river and stream systems and hazardous sites.
- Ontario Regulation 147/06

For more information:

To find out more, please contact Ausable Bayfield Conservation Authority (ABCA) at **519-235-2610** or toll-free **1-888-286-2610** or visit **abca.on.ca** for staff email contacts.

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For a hard copy or alternate format of this document please contact us.

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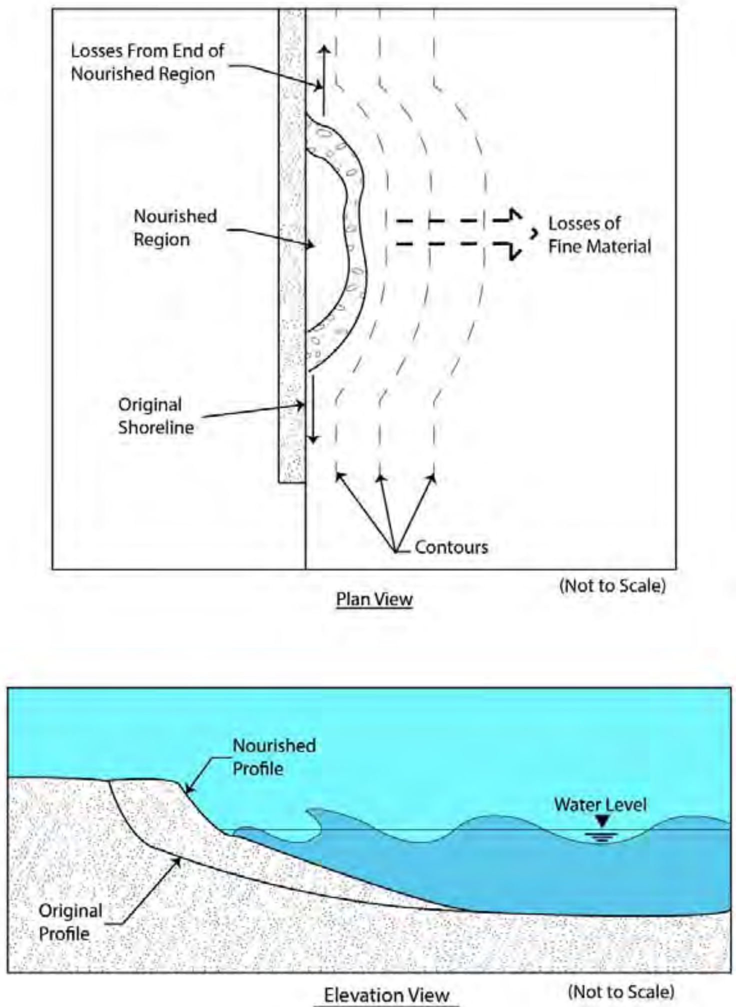
Appendix K: Managing the Hazards References - Beach Nourishment

Managing the Hazards Reference: Beach Nourishment

Beach nourishment increases the sediment supply because it involves the introduction of additional, imported beach material. An increase in the sediment supply may result in decreased long-term erosional stress to downdrift shorelines or even increase the accretion rate. The beaches at adjacent downdrift shorelines may increase in width. The increased width may be of a temporary nature as the nourished material may be transported alongshore until it reaches a sink or deposition area and the downdrift shoreline returns to its previous state. The extent of the impact may extend to the end of the littoral cell. (MNR Part 7, Technical Guide, Pg. 7-77, (2001))



Characteristics of Nourishment Region and Sediment Loss Pathways

Source MNR Part 7 Technical Guide, Figure 7.19 page 7-29.

Beach nourishment is the artificial placement of suitable imported beach material on an eroding or sediment deficient beach area in order to replenish, maintain and/or enhance the beach width. It is considered a structural approach because it is an engineered method that involves the placement of significant quantities of additional material at the shoreline. However, beach nourishment is considered a "soft" structural protection method because it attempts to replicate the natural processes. This additional distinction is noted because no other structural protection work creates sand in the surf zone. Any accumulation of sand produced by a structure, other than beach nourishment, is at the expense of an adjacent section of the shore.

The grain size diameter of the imported beach sediment will generally be the same or larger than the native material to reduce the rate of erosion of the imported material after placement. Beach nourishment typically extends from the backshore area into the nearshore. Depending on the beach width and slope, the added beach material protects the backshore and the nearshore profile from erosion and storm wave damage (see Figure 7.19 above). The increased beach width can also provide recreational benefits. The beach material can be imported from an inland source or obtained by offshore dredging. Beach fill material used should meet the MOECC requirements as outlined in the *Fill Quality Guidelines for Lakefilling in Ontario: Application of Sediment and Water Quality Guidelines to Lakefilling and Policy for Management of Excess Soil, Rock and Like Materials*.

In most cases, beach nourishment will have to be periodically replaced as it is moved downdrift and/or offshore by wave action. This requires a commitment by the proponent for future works (i.e., maintenance and re-nourishment) over the planning horizon of the shore development. The availability and quality of additional beach nourishment material for the complete life-cycle of the project is a major concern. Dedicated sand for the projected life of the project must be identified and committed to the project. **Beach nourishment should be considered as suitable hazard protection for a development only if long-term commitments to maintain the beach nourishment are in place.**

As a result of the "loss" of the placed material from the site, the sediment supply to the littoral zone is increased. In the context of the physical coastal processes, this will usually benefit rather than endanger downdrift areas. A concern that must be evaluated is the effect of the "loss" of the imported material on aquatic habitats adjacent to the site as well as water quality considerations. The amount of silt/clay in the imported material is important because it will determine how turbid the water is during construction, how much fallout and sedimentation will occur, and how much residual silt/clay there will be to be stirred up during storms.

Beach nourishment may be accompanied by "anchoring" or retaining structures, such as groynes, sills, artificial headlands, or detached breakwaters, to reduce the loss of the placed material downdrift due to alongshore transport or towards the offshore due to cross-shore transport. Losses to the offshore are an important consideration for shorelines where cross-shore transport is dominant. When used with retaining structures, beach nourishment is often termed "beach fill". Without the retaining structures, maintaining the placed beach material would be very difficult in areas of rapid erosion (i.e., fine-grained cohesive shores) or where no previous beach existed (i.e., bedrock shores).

Beach nourishment or beach fill can be used in conjunction with other types of shoreline protection works to provide toe scour protection or recreational benefits.

Nourishment projects typically involve the cooperation of many adjacent shoreline property owners because it is generally not a viable approach for short reaches of shoreline. Beach nourishment is not a simple task of just dumping sand on the beach. Like any engineering work in a harsh environment, beach nourishment is a comprehensive undertaking. The design of a beach nourishment project requires a specialized knowledge of coastal processes (e.g., nearshore waves, littoral transport, and interaction with structures) and is often completed with the aid of computer models. Numerical modelling of shoreline processes requires a great deal of experience and expertise to be properly utilized. Further information on modelling can be found in *Cross-Shore Profile Change Models: Great Lakes - St. Lawrence River Shorelines Review and Typical Applications (*Acqua Engineering 1995)

Appendix L: Managing the Environment

Managing the Environment: Environmental Considerations

The following Section highlights some of the key impacts and mitigation measures in the nearshore and backshore areas when considering any activities along the shoreline.

Nearshore Structural Protection Works
Nearshore structural protection works include groynes, headland breakwaters and detached breakwaters. Physical impacts associated with nearshore works (From MNRF, Technical Guide: Part 8 - Table 8.3) include:

Potential impacts to the shoreline ecosystem from protection works in the backshore may occur to terrestrial as well as aquatic habitats. Low-lying areas supporting wetlands may also be impacted. The impacts on the shoreline ecosystem and possible mitigation measures are discussed below.

<u>Increased long-term erosional stress to downdrift shorelines</u>
Backshore and nearshore protection works reduce erosion at the site. This can result in a reduction in the supply of sediments to downdrift shorelines and to the nearshore/offshore area at the site. Impacts to the biological environment are manifested in areas downdrift and offshore of the site and are generally restricted to aquatic habitats.

An alteration of erosion and deposition patterns may result in changes to existing habitat areas. For example, surficial sand/gravel/cobble substrate areas, which are used as fish spawning beds, may be removed resulting in a change to a rock or cohesive substrate. The presence of spawning areas in the site vicinity should be ascertained prior to construction, and the potential for alteration to these areas determined. Methods of reducing such impacts may include modifications to the project design, changes to the location of the structure and/or replacement of lost materials (e.g., sand/gravel/cobble). Any harmful alteration to spawning areas will require compensation.

The reduction in a new supply of surficial sediments (e.g., sand, gravel, cobble, boulders) may reduce the amount and distribution of this substrate in the nearshore area. The amount to which the supply of this material is altered relates to the type and erodibility of the backshore material. For example, the protection of a bedrock cliff will have little effect on the supply of new sand/gravel, or cobble/boulder deposits. A cohesive bluff, however, with a high content of glacial materials may contribute substantially to the supply of coarse materials in the nearshore. Determining the potential for impacts may require an investigation and identification of "source areas" in a regional context. Protection works should not be constructed in critical source areas.

<u>Localized erosion (scour) along toe of and at alongshore ends of protection works</u>
The effects of altering erosion and depositional patterns are generally manifested in the nearshore areas and have the potential to impact on fish and aquatic habitat and wetland areas.
Wave reflection on the protection works may induce localized scour or erosion in front of and at the ends of the protection works. The impacts to fish habitat are usually localized and may involve increased turbidity and smothering of benthic invertebrates. Increased sedimentation in the nearshore area during spawning periods may also result in the covering of eggs and a lower survival rate. Construction should avoid spawning and incubation seasons and areas. Design modifications to reduce impacts include increasing the porosity of the structure and roughness, and flattening the slope of the structure such that it absorbs wave energy.

Scour along the shore edge of the protection works will result in an increase in the water depth and wave activity at the structure. This may mean a loss of the shallow water wave zone that may be used for fish spawning. The design of the structure should include scour protection.

Altered nearshore topography

The placement of any protection work or structure in the nearshore will result in the direct covering of bottom substrate. This may result in the direct loss of fish habitat. The significance of impacts on the productive capacity of fish is related to the nearshore habitat type. For example, exposed bedrock and exposed cohesive substrates have low productivity compared to other substrates such as cobble/boulder and wetland areas. In some instances, the covering of substrates such as exposed cohesive sands by cobbles and boulders will increase habitat diversity and productivity. Studies of artificial reefs placed over a firm compacted sand bottom have shown an increase in colonization of the substrate by invertebrates and forage fish as well as spawning activity by several fish species (Kevern et al. 1985). The potential for spawning activity on the existing substrate should be determined prior to the alteration to substrate materials. The direct loss of spawning areas will require compensation.

In the nearshore, the materials used should attempt to add internal spaces to the protection works. For example, stones and rocks provide crevices where small fish and their food organisms can be protected from predators. Vertical walls with smooth, uniform surfaces, i.e., steel sheet pile, should be avoided as they provide no habitat value.

The alteration of topography in the nearshore may also result in other impacts to the aquatic organisms in the nearshore. An increase of suspended sediments during construction may irritate the gills of fish, place stress on filter feeders and smother benthic invertebrates. Sediment control measures should be used during construction to minimize area impacted by sedimentation and increased turbidity. Placement of the structure may also result in the removal of aquatic vegetation which provides food and shelter for aquatic organisms. These organisms are an essential food source for waterfowl as well as fish. Opportunities for the establishment of aquatic vegetation in adjacent areas should be explored.

Structures or protection works in the nearshore/backshore may also result in the loss of frequently inundated areas. These areas serve as important fish spawning and nursery areas for species such as northern pike, as well as important waterfowl and herpetofauna habitat. Design modifications may include the placement of lower structures.

The occupation nearshore by a structure or protection work is a long-term impact which occurs throughout the design life of the structure or protection works. As area is directly displaced, mitigation is often not able to reduce effects and suitable compensation measures will be required.

Backshore Structural Protection Works

Backshore structural protection works include revetments and seawalls. Physical impacts associated with backshore works (From MNRF Technical Guide: Part 8 - Table 8.3) include:

Decreased long-term erosional stress to downdrift shorelines

Nearshore protection works such as beach nourishment increase the supply of sediment and may result in decreased erosion on-site and at downdrift shorelines.

Accretion updrift and/or in the lee of the structure

Protection works that extend out from the shoreline (e.g., groynes, artificial headlands) or structures located in the nearshore or shallow offshore (e.g., detached breakwaters) may trap surficial sediment updrift and/or in the lee of the structure. Impacts are generally restricted to the nearshore area and may affect the aquatic habitat. The deposition of sediment updrift of the structure may cover spawning substrates. The potential for fish spawning activity at the site and in the area updrift of the site should be determined prior to construction.

Protection works should be designed to minimize intrusion into the nearshore. This may include increasing spaces or gaps between structures. Any harmful alteration to spawning beds is a major impact and will require compensation.

Newly constructed protection works or structures with compartments or crevices, such as a rock rubble groynes, may initially provide suitable habitat for fish such as rock bass, as well as invertebrates (e.g., crayfish). As these crevices are filled in with sediment, the suitability of this habitat decreases. This occurrence should be kept in mind if the design of a structure is to provide a specific type of habitat. The benefit of this type of mitigation may be temporary, as the structure may become filled with sediment.
Accretion updrift and/or in the lee of the structure may result in the alteration of the active wave zone used by some species for spawning. The potential for fish spawning activity at the site and in the area updrift of the site should be determined prior to construction.

<u>Increased erosion at downdrift shorelines until bypassing occurs</u> and/or I<u>ncreased erosion immediately downdrift</u>
Protection works or structures that extend out perpendicular from the shoreline (e.g., groynes, artificial headlands) trap sediments at the site and may result in increased erosion at downdrift shorelines. This also results in the diversion of sediments into deeper waters. Impacts are limited to the fish and aquatic habitat and may include the removal/uprooting of aquatic vegetation and the removal of existing substrates. Utilization of these areas by fish for spawning and nursery areas should be determined prior to construction.

Invertebrates that are carried in the current may be deflected into deeper water where survival rates may be reduced. Impacts may be reduced by designing the structure to minimize intrusion into the nearshore, and/or incorporating suitable materials or spaces to provide for invertebrates.

<u>*Less change of beach and nearshore profile during storms</u>
The beach and nearshore profile will be more stable during storm events. This more protected environment may encourage benthic invertebrates to inhabit these areas and may also result in a change in the dominant vegetation.
*excluding groyne protection works

<u>Induced localized erosion (scour) along the toe of and at alongshore ends of protection works</u>
Refer to previous Section for discussion of potential impacts of inducing localized erosion (scour) along the toe of protection work and inducing localized erosion at the alongshore ends of protection works.

<u>Altered backshore topography at site</u>
Typically, the natural grade of the backshore will be altered by the protection works. For most structures, the grade will be steeper than the natural shore thus limiting access to the shoreline. Alteration of topography in the backshore may also include the grading of this area to a more stable slope. Terrestrial habitat may be impacted by such activities, as well as the adjacent nearshore aquatic habitat. The placement of structures in the backshore, such as seawalls or revetments, usually requires the displacement of the natural terrain and relief and may restrict the access of wildlife, amphibians and reptiles to the shoreline. This impact is likely to be the most significant in low-lying areas. Possible mitigation measures include the provision of access areas such as stepped platforms in the design of the protective structure.

Construction activities may disturb the nesting and migration periods of waterfowl. The timing of construction should avoid these critical periods.

The clearing of vegetation in the backshore may reduce wildlife habitat, may cause an increase in surface runoff and the amount of suspended sediments reaching the watercourse. Natural vegetation should be preserved where possible, or be replanted immediately after construction. Bio-engineering approaches to protective works should be considered where appropriate as they incorporate live plant materials in their design. Removal of overhanging vegetation or shade trees adjacent to the shoreline should be avoided where possible. Sedimentation may be controlled by employing Best Management Practices such as locating stockpiled materials far from the shore and placing a silt curtain around material.

Clearing or removal of vegetation in the backshore may result in the fragmentation of natural corridors along the shoreline, which may interfere with the movement of wildlife along the shoreline. Clearing of vegetation should be minimized where possible and areas cleared should be revegetated.

Altered nearshore topography

Backshore protection works can extend into the nearshore and may alter the shallow wave zone used for spawning by fish species such as alewife and smelt. The design should reduce the extent into the nearshore.

The construction of a protection work usually involves the introduction of new materials to the shore zone. Typical construction materials include steel, timber, concrete, earth fill, quarried stone, sand, gravel, cobble and field stone which may alter the nearshore habitat (i.e., size and internal spaces). Materials used should attempt to add internal spaces to the protection works.