Independent Review of the Sauble Beach Dune Retaining Wall

Prepared By:

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December 1, 2020

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Zuzek inc.
ONE WORLD

Recent Storm Impacts at Sauble Beach with No Dune (road flooding and sand deposition)

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Zuzek Inc. operates a field office in Sauble Beach.

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December 1, 2020

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1.0 INTRODUCTION

The Town of South Bruce Peninsula (TSBP) is proposing to excavate 469 m of coastal dune at Sauble Beach, west of Lakeshore Road, and construct a concrete block retaining wall. The project extends from the Crowd Inn in the south to Kinloss Lane in the north. This report summarizes an independent review of the proposed dune excavation and retaining wall by Pete Zuzek of Zuzek Inc. and Dr. Mary-Louise Byrne from Wilfrid Laurier University. It was based on the technical data submitted by the TSBP for the permit to the Grey Sauble Conservation Authority and other government datasets.

The report includes an overview of known components of the retaining wall design, unknown design aspects, the projected impacts of climate change on the future of Sauble Beach, and potential negative impacts of the project on the beach and dune ecosystem. Best management practices for managing the coastal dunes at Sauble Beach are outlined, including the need for a full impact assessment to justify the proposed destruction of the landward edge of the coastal dune at Sauble Beach.

1.1 About the Authors

The report authors have extensive experience with beach and dune management across the Great Lakes Region and have each observed the beach and dune environment at Sauble Beach for more than 50 years. Their credentials and experience are summarized below:

- **Pete Zuzek, MES, CFM, P.Geo.**: Pete received his Bachelor and Master of Environmental Studies from the University of Waterloo with a focus on coastal processes and geomorphology. He is a Certified Floodplain Manager (CFM) and a Professional Geoscientist. Pete is currently the President of Zuzek Inc. and has 30-years of experience with consulting assignments in the Great Lakes Basin, across North America, and globally on assignments for the United Nations. Refer to his CV in Appendix A for additional information on his project experience and publications.

- **Dr. Mary-Louise Byrne, P.Geo.**: Dr Byrne received her Master and PhD in Geography from McMaster University, where her research focused on the formation and evolution of coastal sand dunes in Prince Edward Island and Sable Island, Nova Scotia. Dr Byrne has 30 years of experience focussed on Great Lakes beaches and dunes. She is currently a Professor and Chair of the Geography and Environment Studies Department at Wilfrid Laurier University, where she received the Award for Teaching Excellence in 2008. Dr Byrne also received the President's Award for Outstanding Service from the Canadian Association of Geographers in 2011 and she received the Faculty Award for Service Excellence and Community Engagement in 2020. Dr Byrne has dedicated her career to advancing the scientific understanding of coastal sand dunes and working with communities to protect these fragile ecosystems.

2.0 Retaining Wall Plan and Potential Impacts

The proposed retaining wall and potential impacts are summarized in Section 2.0.

2.1 Sauble Beach Retaining Wall

The structural design for the proposed retaining wall was completed by BluePlan Engineering and consists of a two-layer concrete block wall at the base of the excavated dune, as noted Figure 2.1. The full drawing is provided in Appendix B. The design states that a soil bearing capacity of 100 kPa is required and should be verified by an engineer prior to block placement. There is no detail in the permit on how such bearing capacity tests will be completed nor who will review the results. The design also specifies the placement of a geotextile fabric behind the block wall prior to backfill. However, there are no specifications for the type of fabric or the placement location in Figure 2.1, which raises questions about whether the geotextile fabric will eliminate the migration of fine sand through the block wall.

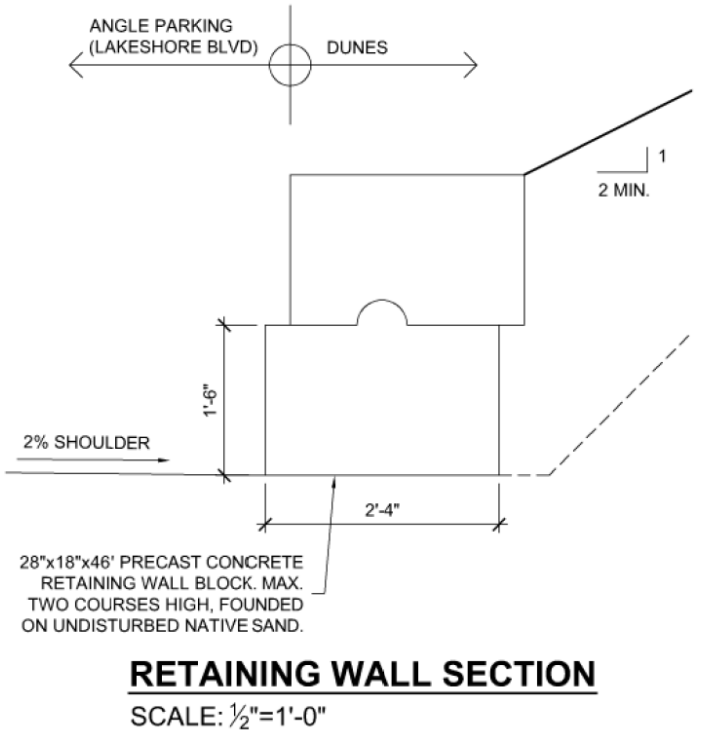

Figure 2.1 Cross-section of Proposed Retaining Wall

The BluePlan Engineering drawing (Appendix B) also states their design work was related to structural aspects of the block wall and the layout would be completed by others. As such, their drawing only includes a very general plan view map showing the spatial extent of the works. Refer to Appendix B. It is not clear if layout work for the proposed dune excavation and construction of the retaining wall was completed, as there were no details in the Grey Sauble Conservation Authority permit number GS20-363. The stability of the proposed 2:1 (V:H) slope in the BluePlan Engineering design lakeward of the block wall is unknown, as is the amount of additional cutting or filling required to achieve this slope.

2.2 Interpretation of the Proposed Layout

In the absence of a layout drawing for the proposed dune excavation, Zuzek Inc. developed the maps in Figure 2.2 and Figure 2.3based on our interpretation of the project from the GSCA permit, the location of the road allowance using a Statistics Canada digital road network file, and GPS coordinates of the excavation stakes installed by the TWBP. The amount of dune excavation appears to range from 0.5 m at the northern limit of the project to over 4 m at the southern limit. It is also worth noting that the overall width of the beach has decreased by 40 m to 50 m between 2015 and present based on recent waterline measurement. Refer to Figure 2.2.

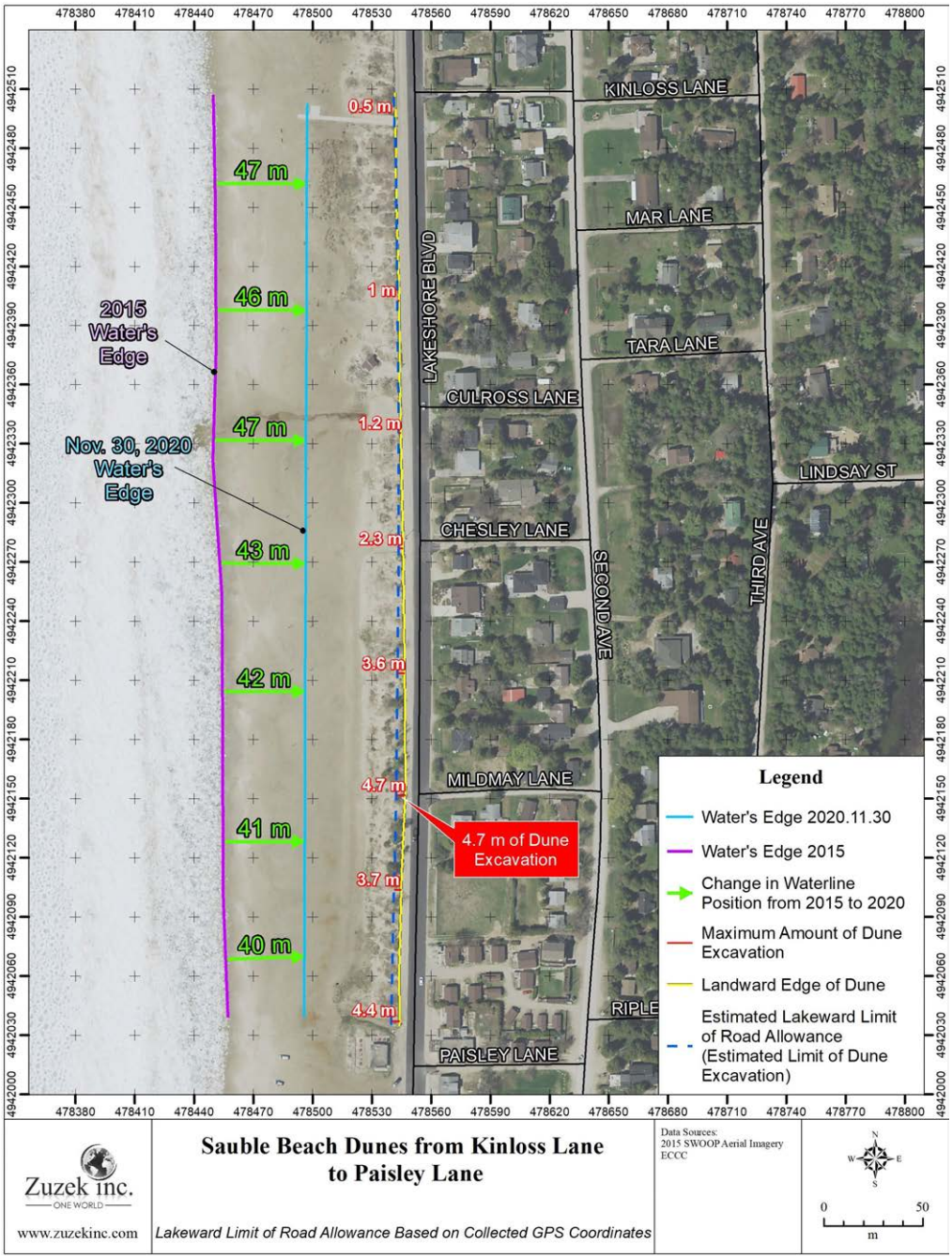

Figure 2.2 Extent of the Proposed Sauble Beach Retaining Wall (Zuzek Inc. Interpretation)

Based on the Zuzek Inc. interpretation of the proposed dune excavation for the southern limit of the project in Figure 2.3, roughly 25% of the coastal dune could be removed and placed in the landfill if this project proceeds. It is also worth noting that the zone of excavation also features mature trees such as poplars and pines that act as a natural wind-break and decrease the rate of aeolian transport (wind blown sand) off the beach and onto the road.

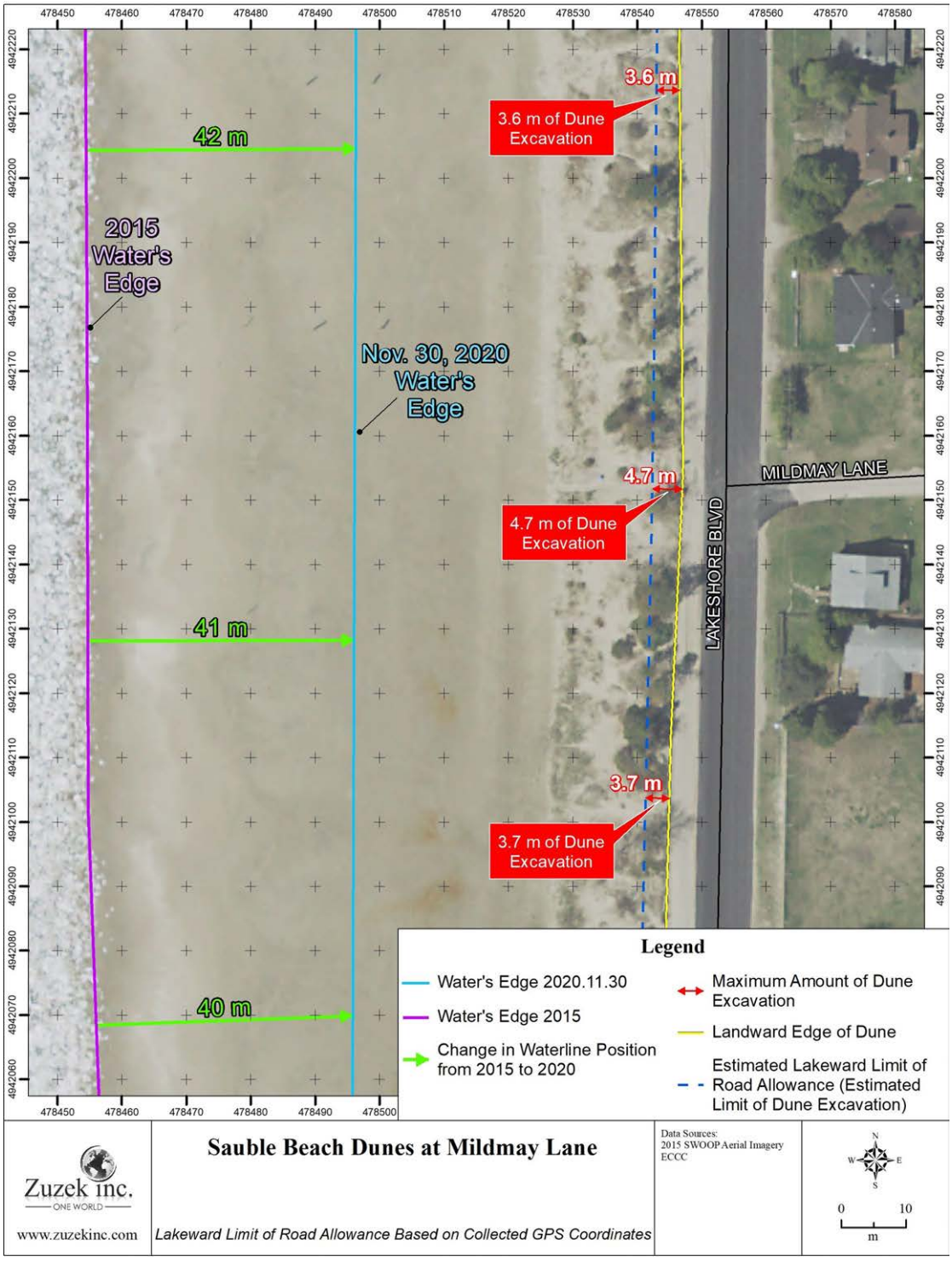

Figure 2.3 Interpretation of Layout at Mildmay Lane

2.3 Beach-Dune Ecosystem at Sauble Beach

The beach-dune ecosystem at Sauble Beach provides a wide range of free goods and services, including flood and erosion protection, resilience to periods of high lake levels, habitat for endangered species, and recreational opportunities. The beach and dune are also part of a dynamic physical system that must be managed and protected as one natural resource. For example, actions at the back of the beach, such as the proposed excavation, cannot be viewed in isolation from the overall health and functionality of the beach. These important inter-relationships were outlined in the 2004 and 2007 Sauble Beach Management Plans prepared by The Lake Huron Centre for Coastal Conservation (LHCCC 2004; LHCCC, 2007).

For example, a healthy beach-dune ecosystem controls the onshore and offshore migration of sand in response to fluctuating lake levels, while maintaining beach resilience. This inter-relationship is depicted graphically in Figure 2.4. During average lake levels, Sauble Beach features a wide sand beach and healthy dune ecosystem (Panel 1) and the nearshore sand bars are in equilibrium with lake levels. When lake levels rise, the beach is flooded, the shallow nearshore zone gets deeper, and the nearshore bars are out of equilibrium (Panel 2). This allows larger storm waves to reach the dune and erode sand that is transported in an offshore direction. As depicted in Panel 3, the sand eroded from the dune re-establishes a shallow nearshore zone during the period of high lake levels. If the back of the dune is excavated, it may not be able to supply sand to the nearshore in the future, as shown in Panel 3. When lake levels drop, waves and currents push sand onshore and aeolian processes transport the sand back into the dune ecosystem, where it remains as a reservoir for the next period of high lake levels. Nature provides beach resilience to high lake levels.

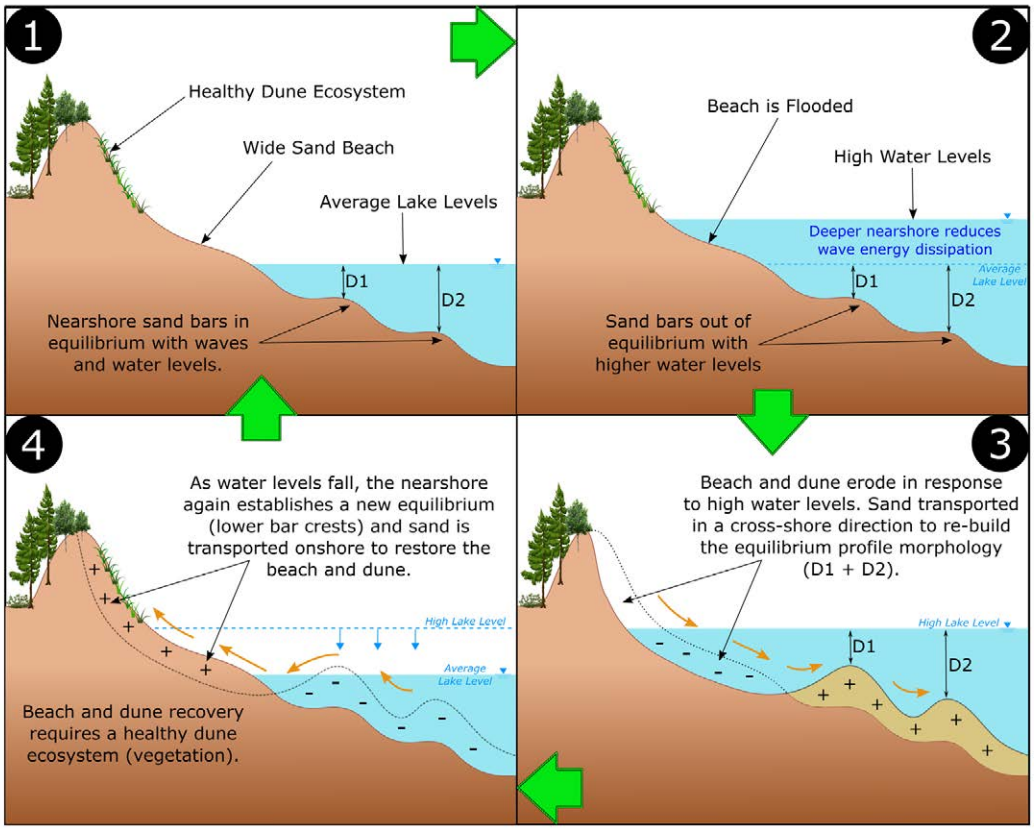

Figure 2.4 Beach-Dune Response to Fluctuating Lake Levels

This dynamic relationship between the beach and dunes at Sauble Beach is a natural response to high lake levels and the presence of a healthy dune is responsible for the overall high resilience of the site. In other words, the beach and dune can recover naturally from periods of high lake levels, as evident by the fact the beach was still accessible when Lake Huron established new record all-time high water levels in the summer of 2020. Refer to the beach conditions opposite Fourth Street North on August 1, 2020 in Figure 2.5. The beach is narrow but functional and supports visitors during the Civic Holiday weekend.

Figure 2.5 Beach Conditions at Fourth Street North, August 1, 2020

The same location was photographed on November 21, 2020 (Figure 2.6) one week after a severe storm impacted the Sauble Beach shoreline on Sunday November 15, 2020. Signs of wave attack into the dune are evident (exposed roots) but the dune protected Lakeshore Boulevard from erosion and flooding.

Figure 2.6 Eroded Beach, November 21, 2020

Compare this to the downtown area. There is no dune on the beach north of Main Street and the Sauble sign where the response to the November 15, 2020 storm was different (Figure 2.7). Storm waves were able to flood the entire beach and road, and deposit sand across the road and on the east side of Lakeshore Boulevard North. Without a coastal dune, the section of Sauble Beach has low resilience to coastal storms and high lake levels. Storms during high lake levels threaten the commercial real estate.

Figure 2.7 Beach North of Main Street, November 19, 2020

The block promenade constructed adjacent to the Sauble sign is now more than 50% destroyed. See Figure 2.8. Most of this artificial structure, which features quarried blocks, has not survived the current period of high lake levels. Unlike a healthy beach-dune ecosystem, there are no natural response mechanisms in this engineered addition to the beach.

Figure 2.8 Failed Block Promenade at Sauble Sign, November 19, 2020

2.4 Limited Sand Resources and Aeolian Transport

The sand in the Sauble Beach embayment from the mouth of the Sauble River at Chief's Point to Frenchman's Bay is a relict deposit from the recent post-glacial period (i.e., deposited over the last 10,000 years). Unlike beaches further to the south in Goderich, Bayfield, and Grand Bend, which are nourished by the erosion of sand and gravel in the adjacent bluffs, there is no new supply of sand to Sauble Beach. Therefore, a healthy dune ecosystem is required to trap and retain every grain of sand in the system. The plan to excavate up to 4 m of the coastal dune and truck the sand to the landfill may be detrimental to the overall health and resilience of the coastal dune at Sauble Beach. It does not appear that this issue was investigated by a qualified professional, such as a coastal engineer or geoscientist, to substantiate the permit request. In addition, in the absence of a proper layout drawing, such as the Zuzek Inc. interpretation of the proposed design in Figure 2.2 and Figure 2.3, it is unclear if the volume of excavation has been calculated.

Any sand transported off the beach and onto the road surface should be placed back on the beach. If the Regulatory Authorities identify potential contamination, an inexpensive and routine environmental test can be completed to evaluate the quality of the sand. As noted in the 2004 Beach Management Plan: Conserving a Finite Resource, every grain of sand is important at Sauble Beach (LHCCC, 2004). Putting Sauble Beach in the landfill is not a sound beach management strategy.

In addition to the excavation of sand and sensitive dune grass species, the proposed plan by the TSBP results in a large number of mature trees removed, such as the stand of the trees seen in Figure 2.9. These mature trees and shrubs are a natural barrier to the transport of sand over the dune system and onto Lakeshore Boulevard North. Removal of these mature trees will accelerate the loss of sand from the beach and dune ecosystem, cause more beach erosion, and increase road maintenance.

Figure 2.9 Mature Trees in Cutline to be Removed (image courtesy J.Stafford, November 30, 2020)

2.5 Destruction of Dune Species and Endangered Species Habitat

The dunes at Sauble Beach have high biodiversity and feature plants that are globally and provincially rare (LHCCC, 2004). These plant communities and the open beach provide habitat for the endangered piping plover, which has successfully nested and fledged chicks from the beach. The Ministry of the Environment, Conservation, and Parks (MECP) have determined the beach at Sauble is habitat for the endangered piping plover and have recently fined the TSBP for illegal raking of the beach vegetation. It is unclear how the excavation and permanent removal of dune sand, plants, and mature trees are not considered destruction of the piping plover habitat. As stated in Section 2.3, the beach and dune at Sauble are one integrated and inter-related ecosystem. Even small damage to the dune ecosystem can have incremental and cumulative impacts to the overall health and integrity of this ecosystem. We are not aware of any such impact assessment to assess incremental and cumulative impacts by a qualified geoscience professional, which is a significant omission.

2.6 Historical Lake Levels and Climate Change

The potential impacts of climate change on physical processes along the coastlines of the Great Lakes was recently investigated with financial support from the Natural Resources Canada Adaptation Program (Zuzek Inc, 2019; Zuzek Inc., 2020). The key findings from this first-of-its-kind investigation and relevance for the proposed Sauble Beach dune retaining wall project are reviewed.

2.6.1 Lake Huron Water Levels

The measured water levels on Lake Huron from 1918 to 2019 are summarized in Figure 2.10 which highlights the long-term trend of rising and falling lake levels over the last 100-years. Prior to the record high water levels recorded in the summer months of 2020, the last period of high lake levels was 1986. For more than 20-years, Lake Huron water levels were average to low, and the beach at Sauble was very wide. Then, record levels of precipitation in the Great Lakes Basin from 2017 to present resulted in record setting lake levels in the summer of 2020.

For coastal planning and hazard management, the Ministry of Natural Resources (1989) published a report on extreme water levels for the Great Lakes. The 100-year lake level, which has a statistical probability of occurrence of 1% in any given year, for the Southampton-Sauble Beach region of Lake Huron is 177.67 m IGLD'85. This level is also plotted on Figure 2.10, as the horizontal yellow line. It consists of static lake levels and the affects of storm surge, which is the short-term rise of the lake surface during storm events.

The projected impacts of climate change on future lake levels was recently investigated by Environment and Climate Change Canada (ECCC Open File, 2020). There are two important changes in future lake levels attributed to higher precipitation. First, the mean lake levels are projected to increase over time and periods of lows, such as recently experienced will be less frequent. And during wet periods, such as the current conditions, Lake Huron water levels are projected to be 0.5 m higher by mid-century (2050) and 0.95 m higher by late-century (2080).

The current period of high lake levels is challenging the resilience of coastal communities throughout Lake Huron. It is incumbent on communities to quantify climate change impacts, such

as higher lake levels, and plan for an uncertain future. A healthy dune and beach ecosystem is the best line of defence against high lake levels and should be the cornerstone of the beach management strategy at Sauble Beach.

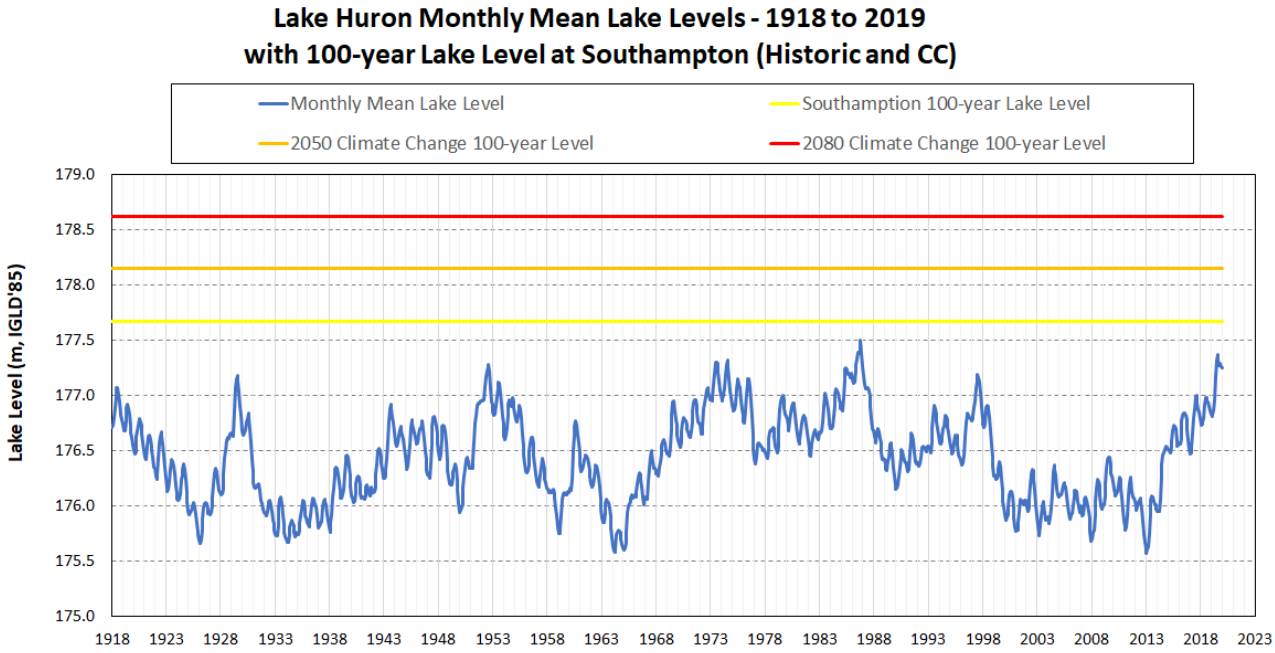

Figure 2.10 Historical Lake Huron Water Levels and Future Projections (ECCC)

2.6.2 Temperature, Ice Cover, and Storm Exposure

The projected winter warming in Canada for Representative Concentration Pathway (RCP) 2.6 and RCP8.5 were recently summarized by Bush and Lemmen (2019). By late century, winter temperatures for RCP8.5 could be 5 to 7 degrees Celsius warmer, which could eliminate the existence of lake ice cover leading to storm exposure all year.

Reduced ice cover in the Great Lakes has been documented already (Wang et al, 2012), with similar trends noted throughout the northern hemisphere (Sharma et al, 2019). When the projected warming of winter air and lake temperatures were recently investigated on Lake Erie for RCP8.5 (Zuzek Inc., 2019), the data suggest that Lake Erie could be permanently ice-free by late century (2080). The progressive loss of Lake Erie ice cover is shown schematically in Figure 2.11. A similar investigation has not been completed on Lake Huron, however, the future climate data projects similar air and lake temperature increases. If Lake Huron ice disappears, Sauble Beach will be exposed to more erosive coastal storms in winter.

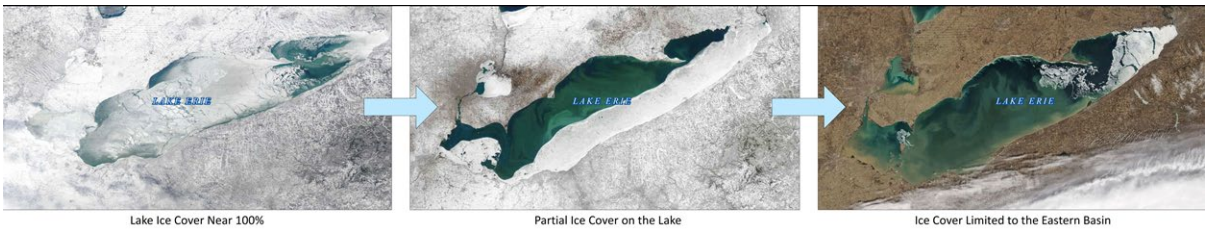

Figure 2.11 Projected Changes in Lake Erie Ice Cover due to Climate Change

To investigate the potential risk of ice-free winters on storm exposure, Zuzek Inc. (2019) completed a numerical modelling study where historical wave energy when Lake Erie featured ice in the winter was compared to a late-century (2080) projection when Lake Erie would be ice-free. The amount of winter wave energy or storm exposure increased by 70 to 120%, as noted in Figure 2.12. While a similar lake-specific study has not yet been completed for Lake Huron, the climate data points to similar impacts at Sauble Beach.

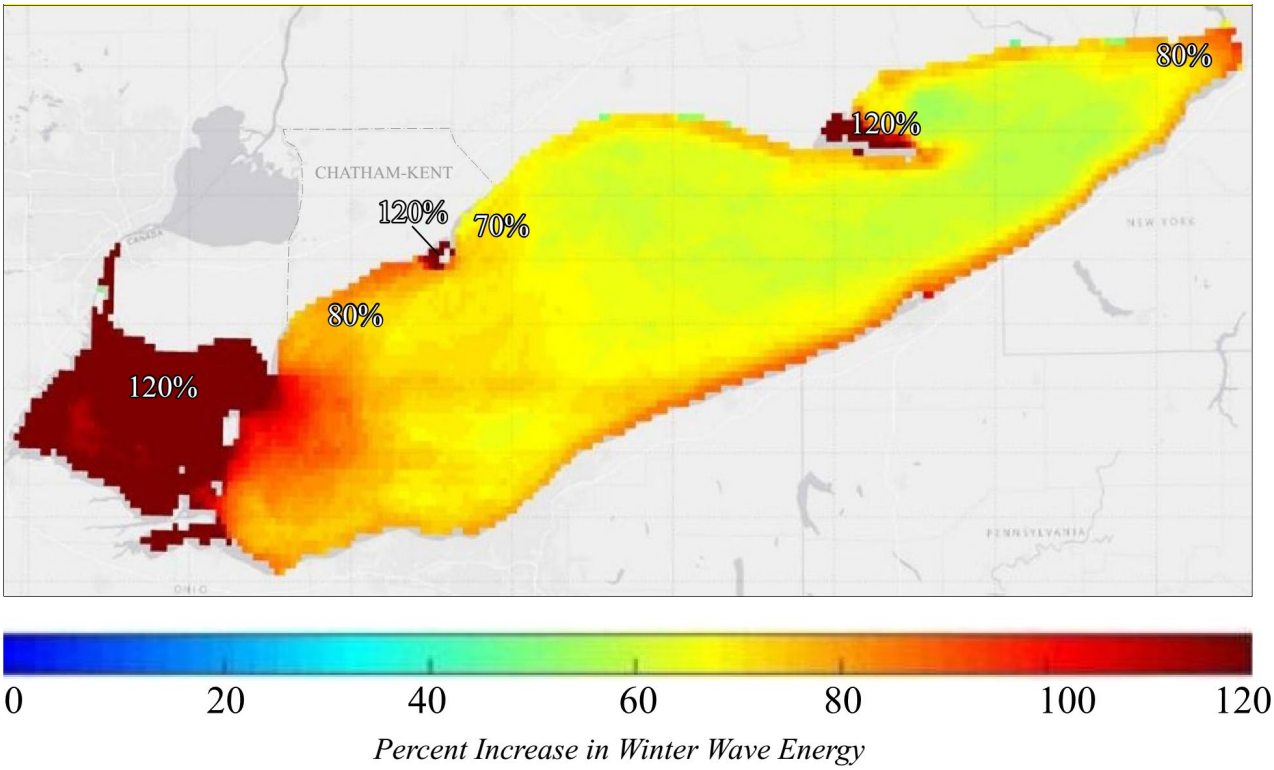

Figure 2.12 Projected Increase in Winter Wave Energy for an Ice-Free Lake Erie

If similar trends emerge on Lake Huron, beach and dune erosion along with flood risk will increase dramatically at Sauble Beach. In short, the relatively ice-free winter of 2019-2020 is a prelude to the future. The waterline has already retreated 40 to 50 m inland in the proposed construction zone. Excavating the coastal dune at Sauble and trucking the sand to the landfill is not an effective adaptation strategy to coastal erosion and flooding threats.

3.0 BEST MANAGEMENT PRACTICE

This independent review of the Sauble Beach dune retaining wall has highlighted numerous shortcomings of the proposed plan, potential negative impacts, and missing analysis. Section 3.0 highlights best management principles that should be adopted at Sauble Beach to increase the resilience of the beach-dune ecosystem to mitigate existing threats and future impacts associated with climate change.

3.1 Integrated Coastal Management

Integrated coastal management recognizes the linkages between the physical, ecological, and social systems when developing long-term management strategies. Given the inter-relationship between the physical processes, ecology and habitat, and human use of Sauble Beach, integrated coastal management provides a framework for developing balanced long-term sustainable management plans. The current plan to excavate up to 4 m (12 feet) of the coastal dune, landfill the sand, and replace this functional natural ecosystem with a concrete retaining wall is not consistent with integrated coastal management. It is a short-sighted response to one issue (traffic and pedestrian safety) that ignores the potential negative impacts to the physical-ecological system.

3.2 Working with Nature

The limitations with grey infrastructure to address coastal hazards, such as concrete block walls and the quarried block wall constructed adjacent to the Sauble sign, have been known for many decades (Fisheries and Oceans Canada, 1981), yet communities still turn to these ineffective strategies. Recently, new paradigms have emerged such as Engineering with Nature (Bridges et al, 2018) and Nature-based Solutions to address coastal hazards, resource management challenges, and adapt to climate change (IUCN, 2020). These concepts embrace solutions that work with nature, not against it, and strengthen protection of coastal assets while also enhancing the ecosystem. At Sauble Beach, potential nature-based solutions include beach nourishment (trucking suitable sand to the beach from upland sources), restoration of the dune vegetation, active management of beach access points, and long-term adaptative management to monitor change.

The northern half of Sauble Beach features a relatively resilient beach and dune ecosystem, with some challenges due to pedestrian access, vegetation trampling in the dunes, and car parking. The TSBP is encouraged to enhance the existing beach and dune ecosystem to provide flood and erosion protection naturally, protect habitat for endangered species, and build resilience so that the beach is accessible to users regardless of the future lake level trend. This new approach would begin by abandoning the plan to excavate the dune and build a dune retaining wall.

3.3 Consider Alternatives

Public safety is an important aspect of beach management but ignoring the potential negative impacts of excavating up to 4 m of the coastal dune is not consistent with best practice. While it is not the intention of this independent review to design alternatives to the proposed dune retaining wall for the TSBP, there are numerous alternatives that could address the public safety

concerns subject to a proper traffic study by a qualified professional, while also protecting the beach-dune ecosystem, including:

- **Convert the Project Area to Parallel Parking**: The angled parking could be converted to parallel parking to improve safety. Parking at the controlled beach access points could be designated for visitors with special accessibility needs. Reducing the density of the parking would also be a pro-active strategy to protect the beach users from COVID-19 exposure.

- **Spend the $150,000 budget on Alternative Parking**: Rather than decreasing the resilience of the beach and dune ecosystem, spend the budgeted $150,000 on alternative parking locations to address demand on busy summer weekends.

- **Convert Lakeshore Boulevard to One-Way Traffic**: A single lane of traffic, heading north, would eliminate all safety concerns with angled parking. The current eastern lane could be converted to a dedicated bike lane to increase safety for carbon neutral alternative transportation. The current east shoulder could be designed as a safe walking trail.

- **Charge a Premium for Parallel Parking Adjacent to the Beach**: A two-tiered parking fee system could be implemented, with a premium associated with parallel parking and the current fee charged for parking on the side streets and Second Avenue. The additional revenue from the premium parking could be used to hire more enforcement officers onsite to enforce bylaws during the busy summer period.

- **Request a Reduction in the Speed Limit**: Reducing the speed limit on Lakeshore Boulevard North and proper enforcement would improve safety.

4.0 SUMMARY

Section 4.0 summarizes our independent review of the Sauble Beach dune retaining wall, including unanswered questions, potential negative impacts, and recommendations:

Unanswered Questions

- From the review of the BluePlan Engineering design and the GSCA permit, is not clear:
    - What type of geotextile fabric will be used, how it will be placed adjacent to the concrete blocks, and whether it will be effective at reducing sand migration through the wall.
    - Testing procedures to establish the in-situ bearing capacity are not outlined.
    - The spatial extent of the project was not mapped, and the volume of dune excavation has not been documented, to our knowledge.
    - Rare and endangered plant species have not been documented.
- The protected impacts of climate change, such as higher lake levels, ice free winters, and increased exposure to coastal storms has not been addressed.
- It does not appear that a proper impact assessment by a qualified geoscience professional was completed, thus potential negative impacts have not been investigated and/or been mitigated with the design.

Potential Negative Impacts

- The incremental and cumulative impacts of excavating the back of the dune could decrease the resilience of the beach and dune ecosystem and destroy habitat.
- The natural flood and erosion protection provided by the dune may be compromised.
- Removing dune grasses, shrubs, and mature trees at the back of the dune will reduce the trapping potential for wind-blown sand and may accelerate deposition of sand onto the road, which will negatively impact the beach and increase maintenance costs.
- The volume of sand at Sauble Beach is a finite resource and there are currently no natural sources transporting new sand to the embayment. Any purposeful removal of sand may have a permanent negative impact on beach width and dune health.

Recommendations

- Embrace integrated coastal zone management principles and manage Sauble Beach as an inter-related physical, ecological, and social system. Single issue management, such as public safety, is the opposite of integrated coastal management.
- Implement nature-based solutions to increase beach and dune resilience to coastal hazards and projected climate change impacts.
- Collaborate with the community and stakeholders on the development of sustainable long-term management strategies for Sauble Beach.
- Do not put Sauble Beach sand in the garbage.

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APPENDIX A

CVs of the Authors

Peter J. Zuzek, MES, CFM, P.Geo.
President

QUALIFICATIONS

PROFILE

Peter Zuzek is the founder and President of Zuzek Inc., a professional services company dedicated to increasing the health and resilience of the world's coastal ecosystems. He has 30 years of experience managing complex multi-disciplinary coastal investigations throughout North America and internationally. Services include coastal erosion and flooding studies, risk assessments, coastal zone planning, shoreline management plan development, water quality investigations, habitat protection and restoration, nature-based solutions, climate studies, and development of climate change adaptation strategies.

EDUCATION

Master of Environmental Studies, University of Waterloo
Bachelor of Environmental Studies, University of Waterloo

ASSOCIATIONS

Professional Geoscientist, Association of Geoscientists of Ontario
Certified Floodplain Manager, Association of State Floodplain Managers
President, Coastal Zone Canada Association

EMPLOYMENT HISTORY

Zuzek Inc. 2016 - present, President
Baird & Associates 1994 - 2016, Project Manager

SHORELINE PLANNING AND MANAGEMENT

Coastal Hazard Management in the Great Lakes – A Call to Action to Prepare for a Changing Climate

Financial Support: Natural Resources Canada

In partnership with Linda Mortsch from the University of Waterloo, Zuzek Inc. prepared a White Paper to outline the need to address Climate Chang impacts hazard regulations in Ontario, which were developed on the assumption of climate stationarity. More than 20 Conservation Authorities were engaged to get feedback on existing challenges and develop a path forward to integrate the evolving risk profile.

Chatham-Kent Lake Erie Shoreline Study

Client: Municipality of Chatham-Kent and the Lower Thames Valley Conservation Authority

Project Manager for Chatham-Kent Lake Erie coastal risk assessment. Technical studies and planning engaged a broad spectrum of stakeholders to evaluate hazards, map vulnerability, quantify risks, and develop community-scale climate change adaptation plans to increase resilience.

Town of Lakeshore Shoreline Management Plan Update

Client: Town of Lakeshore

Zuzek Inc. was retained to update the original Shoreline Management Plan prepared in 1976. Historical data on waves and lake levels, plus the latest projections for Climate Change influence on future lake levels and ice cover was integrated into the hazard mapping and regulatory setbacks.

Southeast Leamington Graduated Risk Floodplain Mapping Project

Client: Municipality of Leamington

Pete was the Project Manager for a comprehensive coastal flood risk assessment for Southeast Leamington, that included future projects for climate change impacts on lake levels, future erosion, and shoreline protection maintenance. Potential economic damages were calculated for three flood risk scenarios. Community scale adaptation plans were developed in consultation with the stakeholders.

Southeast Leamington Hazard Identification and Risk Assessment (HIRA)

Client: Municipality of Leamington

Completed a hazard identification and risk assessment (HIRA) for the community of Southeast Leamington. The report focused on hazards, change over time due to shoreline and lake bottom erosion, a risk assessment, and recommendations for monitoring. Updated floodplain mapping was recommended.

Long Point and Walsingham Forest Priority Place Cloud Mapping Application

Client: Long Point World Biosphere Reserve Foundation

Zuzek Inc. was retained by the Long Point World Biosphere Reserve to develop a cloud-based mapping application to store and visualize geo-spatial data for the Priority Place.

Lower Trent Shoreline Management Plan Update

Client: Lower Trend Conservation Authority

Zuzek Inc. was retained by the Lower Trent Conservation Authority to complete a shoreline management plan update. The shoreline was sub-divided into reaches based on geomorphic conditions of the shoreline and updated flood and erosion hazard setback mapping was prepared.

Central Lake Ontario Shoreline Management Plan Update

Client: Central Lake Ontario Conservation Authority

Project manager for an update of the 1990's shoreline management plan for CLOCA. The study included oblique aerial photographs, comprehensive field observations, numerical modeling, and updated hazard mapping.

Ganaraska Region Shoreline Management Plan Update

Client: Ganaraska Region Conservation Authority

The Ganaraska Region shoreline was the focus of a recent shoreline management plan update by Zuzek Inc. Detailed field observations and drone photography was collected, followed by updated extreme value analysis and numerical modeling. New mapping for the hazardous lands along Lake Ontario was generated.

Adapting to the Future Storm and Ice Regime in the Great Lakes

Financial Support: Natural Resources Canada

Project Manager for the first climate change investigation in the Great Lakes dedicated solely to evaluating the impacts of future coastal storm extremes and trends in ice cover on coastal communities and ecosystems. The data was mainstreamed into four adaptation case studies to increase community resilience.

Fortress of Louisbourg Sea Level Rise Adaptation Plan

Client: Parks Canada Agency

Project Manager for the Fortress of Louisbourg sea level rise adaptation plan. The site faces numerous natural hazards, including sea level rise, crustal subsidence, and exposure to severe storms from the North Atlantic. A series of mitigation plans were developed for the Grand Etang barrier beach and seawall.

Elgin County Shoreline Management Plan (SMP)

Client: Elgin County and Four CA's (Lower Thames, Kettle, Catfish and Long Point Region)

Project Manager for the Elgin County SMP update. Technical studies included a detailed field reconnaissance of 90 km of shoreline, measurement of historical shoreline erosion rates, and flood risk assessment for low lying lands. Various shoreline management options were developed based on the technical findings and policy guidance. A joint SMP was written for the four CAs.

Victoria Beach Integrated Shoreline Management Plan

Client: Rural Municipality of Victoria Beach

The coastal community of Victoria Beach is located on narrow peninsula in the southern basin of Lake Winnipeg. Pete managed a three-part study that culminated in the development of the Shoreline Management Plan to help the community address coastal hazards and maintain beach access. The technical work included a governance review, technical studies, and public engagement to develop the SMP.

Shoreline Restoration and Management Plan, Indiana Dunes National Lakeshore

Client: US National Parks Service

Contributed to a multi-disciplinary investigation to development a shoreline restoration and management plan for the Indian Dunes National Lakeshore. The coastal dune habitat features some of the most ecological diverse habitat in the Great Lakes Region and, yet, is threatened by coastal development, park visitors, harbours that disrupt littoral drift, and invasive species.

Regional Programme for the Sustainable Management of Coastal Erosion and Sea Level Rise in the Seas of East Asia

Client: United Nations Environmental Programme

Retained by the UNEP to develop a strategic policy document on coastal erosion and sea level rise for the Coordinating Body of the Seas of East Asia (COBSEA). Phase 1 focused on country consultations and the framework development. In Phase 2, a one-week workshop was held in Thailand with the 10 member countries to refine the approach and finalize the document which was published by the UN.

Southeast Leamington Sustainable Management Strategy

Client: Essex Region Conservation Authority

Managed a complex multi-disciplinary investigation that included coastal process modelling, water quality studies, erosion and flooding assessments, dyke geotechnical analysis, biodiversity assessments, and tourism economics. A benefit-cost analysis was used to evaluate alternative land use scenarios for the region, culminating in the selection of the preferred sustainable alternative.

Colchester to Southeast Shoal Littoral Cell Study

Client: Conservation Authority, Municipal Governments, and Industry

Led a comprehensive study on erosion and sedimentation processes for the littoral cell including Point Pelee National Park The investigation looked at historical sediment supply rates from erosion, sediment sinks, and depositional areas. The findings highlighted the negative impact of shoreline armouring on the park.

Regional Sediment Management Plan for Michigan City Harbor

Client: US Army Corps of Engineers, Detroit District

Managed a study on sediment bypassing at Michigan City. A long-term sediment budget was used to quantify sediment sources, transport pathways, and sinks along the coastline. The findings were used to develop a multi-agency regional sediment management plan to optimize sediment dredging and placement.

Ministry of Natural Resources Integrated Coastal Zone Management Review

Client: Ministry of Natural Resources and Forestry

In cooperation with Dr. Larry Hildebrand and Dr. Peter Ricketts, Pete managed a study for the Ministry of Natural Resources and Forestry on options to apply Integrated Coastal Zone Management principles in the Great Lakes Region. The report reviewed existing legislation, actions in other jurisdictions, and International case studies. Options for better integration and collaboration among government agencies and the steps required to achieve the stated goals were outlined.

Climate Change Impacts on Lake Ontario Coastal Processes

Client: Department of Fisheries and Oceans (DFO)

Retained to investigate the potential impacts of climate change on Lake Ontario coastal processes. Hourly wave conditions were predicted for the historical 1971 to 2000 over-water winds and the estimated future 2041 to 2070 over-water winds from the Canadian Regional Climate Model. In addition to evaluating the intensity and frequency of future storms versus historical conditions, the hourly waves from both scenarios were used in an erosion model to quantify recession rates and the availability of new sediment for beach building. The results were used to assess potential impacts to fish habitat by DFO.

Climate Change and Policy Workshop

Client: Ministry of Natural Resources and Forestry & Environment and Climate Change Canada

Coordinated a large two-day coastal policy forum to review the status of existing regulations and investigate the degree to which climate change considerations were presently integrated. Recommendations were provided on required technical studies and the need for a White Paper on integrating climate change risk into the existing planning and regulatory framework.

Climate Change Risk Assessment for Coastal Infrastructure in Nova Scotia

Client: Nova Scotia Department of Transportation and Infrastructure Renewal

Managed a preliminary coastal risk assessment for several highway and bridge sites in Nova Scotia exposed to coastal hazards during storms. Event based hazards such as storm surge, erosion, and flooding were investigated, along with long-term processes such as sea level rise and crustal subsidence. Management alternatives were developed to reduce risks and future maintenance of the infrastructure.

EROSION AND SEDIMENTATION PROJECTS

Synopsis of Point Pelee National Park Erosion and Mitigation Options

Client: Parks Canada

Prepared a synopsis of shoreline erosion processes and rates within Point Pelee National Park spanning the last 100 years. Updated mapping of recent erosion rates was also generated along with forecasts of future shoreline position to assess infrastructure risks and potential habitat loss. A variety of erosion mitigation strategies were highlighted, include beach nourishment options that work with natural processes.

Lac Seul Erosion Investigation

Client: Aboriginal Affairs and Northern Development Canada

Principal investigator and project manager for the Lac Seul erosion investigation. A comprehensive field program, literature review, and computer modelling were completed to generate multiple lines of evidence on the pre- and post-dam erosion rate on Lac Seul. Expert witness testimony provided in the Supreme Court of Canada.

Lake Winnipeg Water Level Regulation Review

Client: Manitoba Clean Environment Commission

Prepared an expert report on the impacts of Lake Winnipeg water level regulation on shoreline erosion and accretion processes. The critical factors controlling erosion were reviewed, along with the influence of fluctuating water levels (both natural and regulated). Presented findings at a hearing in Winnipeg and provided recommendations for future technical studies.

Ochiichagwe'Babigo'Ining Ojibway Nation Erosion Study

Client: Ochiichagwe'Babigo'Ining First Nation

Project Manager for two technical studies for the Ochiichagwe'Babigo'Ining Ojibway Nation. The first investigation focused on the linkages between water level regulation, flooding, and erosion associated with the Lake Woods water management regime. The second investigation developed conceptual design alternatives to protect critical infrastructure at risk to erosion and flooding.

Mitaanjigamiing First Nation Erosion Study

Client: Mitaanjigamiing First Nation

Project Manager for a two-part investigation for the Mitaanjigamiing First Nation on Rainy Lake. Part one included detailed site reconnaissance of the shoreline to identify potential erosion sites and critical infrastructure at risk to erosion and flooding hazards. Part two included the generation of design alternatives to protect critical infrastructure at risk to flooding for the upper portion of the easement and ensure the waterfront and boat launch were functional for the anticipated range of future lake levels.

Lac Des Mille Lacs Erosion Study

Client: Lac Des Mille Lacs First Nation

A multi-day field data collection mission was completed on Lac Des Mille Lacs. The information, along with desktop studies, were used to evaluate the impact of water level regulation on shoreline erosion within the Reserve. Recommendations were also provided for a flooding easement and critical infrastructure was identified that was vulnerable to flooding. Engineering designs were prepared to protect at risk buildings.

Whitesand First Nation Erosion Peer Review

Client: Ontario Power Generation

Retained by Ontario Power Generation to complete a peer review of documented erosion procession on the north shore of Lake Nipigon, within the limits of the Whitesand First Nation. The study included a review of the water level regulation on the lake and the influence on erosion processes. Detailed erosion measurements were completed to assess risks and make recommendations for erosion protection.

Lake St. Joseph Erosion and Flooding Assessment

Client: Attorney General of Canada and Ontario Power Generation

Served as an expert witness in the legal proceedings between the Mishkeegoggamang Ojibway First Nation and the Attorney General / Ontario Power Generation. A detailed field investigation was completed to collect erosion and sedimentation data. These data, along with historical references, shoreline change measurements, numerical modelling and expert judgement were used to formulate an opinion on the role of the lake flooding on erosion processes. Testimony was provided in the Ontario Provincial Court.

Gull Lake Wave Database

Client: Manitoba Hydro

Project Manager for a numerical modelling investigation on Gull Lake, in northern Manitoba. An hourly wave database was generated for the planned reservoir at full supply to support wave erosion modelling. The wave database was delivered in an interactive ArcReader GIS application.

Lake Diefenbaker Erosion Assessment

Client: Environment Canada

As Project Manager for the study, Pete was responsible for supervising the calculation of historical erosion rates, wave modelling, and shoreline erosion modelling with COSMOS. The COSMOS tool was used to investigate historical erosion rates and evaluate future water level management scenarios.

East Harbor State Park Erosion Investigation, Lake Erie

Client: Ohio Department of Natural Resources (DNR)

Retained by the Ohio DNR to evaluate erosion issues within the State Park and recommend remedial options to improve the swimming beach conditions. Technical studies included literature review, site surveys, aerial photograph analysis of historical shoreline change rates, sediment transport calculations, and a regional sediment budget. The preferred alternative included a series of low crested offshore breakwaters and beach nourishment.

Erie Shore Drive Flood and Erosion Study, Lake Erie

Client: Municipality of Chatham-Kent

Managed the investigation of coastal hazards for the community of Erie Shore Drive. The study included field work, modelling of coastal processes, erosion and flooding assessment, and the development of remedial options. A preferred option to protect the homes and dyke was developed.

Investigation into Downdrift Erosion Impacts, Shade Beaches, PA

Client: Harborcreek Township, Pennsylvania

Managed the investigation into potential downdrift impacts of a proposed harbor development on Lake Erie. The work included field reconnaissance, geology and erosion assessment, longshore sediment transport calculation, and a harbor bypassing analysis.

NIPSCO Bailly Station Intake Sand Transport Investigation, Indiana

Client: NIPSCO

Led the coastal investigation into sedimentation processes at the NIPSCO Bailly Station water intake. Numerical tools and GIS were used to quantify rates of sediment transport and accretion around the intake. The study recommended remedial measures to reduce sedimentation and dredging in the future.

Minnesota Point Section 111 Erosion Study Report

Client: US Army Corps of Engineers

Managed the investigation into erosion and sedimentation processes at Minnesota Point, Lake Superior, which features two jetted navigation channels and a long barrier beach system. Numerical modelling of waves and sediment transport in combination with shoreline change measurements, sedimentation records, and dredging history were used quantify erosion processes. Recommendations included relocating future dredged sediment to mitigate the ongoing shore erosion and nourish the beaches.

Toronto Islands Erosion Study

Client: Toronto and Region Conservation Authority

Led the coastal investigation into erosion processes at the Toronto Island. The technical studies included a review of historical aerial photographs, quantification of historical bathymetric changes, and numerical modelling of waves, currents and sediment transport to develop a detailed sediment budget. The sediment budget was used to quantify historical and modern sediment sources, transport pathways, and sinks. Long-term management recommendations were developed to reduce future shore erosion.

Keltic Lodge Coastal Erosion Study, Cape Breton, Nova Scotia

Client: Nova Scotia Department of Transportation and Infrastructure Renewal

Principal investigator in the study of coastal erosion hazards at the Keltic Lodge site, located on the narrow Middle Head Peninsula in Cape Breton. Erosion of the weak sea cliffs was threatening buildings and the transportation network. Remedial options were developed based on the geologic assessment, groundwater processes, wave climate, and sea level rise considerations.

FLOODING PROJECTS

FEMA Guidelines and Specifications for Coastal Floodplain Mapping

Client: Federal Emergency Management Agency (FEMA)

FEMA generates and updates graduated floodplain risk maps for all the rivers and coastal areas of the United States. Pete participated in a multi-team initiative to update the Guidelines and Specifications used to produce the mapping. The technical studies included the evaluation of the latest wave runup and overtopping procedures, wave and storm surge modelling capabilities, and overland wave propagation.

FEMA DFIRM Production for Kandiyohi and Eaton Counties

Client: FEMA Region V

Managed the technical studies and generation of digital flood insurance rate maps (DFIRMS) for two riverine counties in the State of Michigan. More than 100 standardized map tiles were generated to map the spatial extent of the 1% and 0.2% chance flood risks. The final products were delivered in a GIS Geodatabase and as PDF maps.

FEMA DFIRM Production in Wayne and Monroe Counties

Client: FEMA Region II

Managed all activities related to the coastal analysis and generation of floodplain work maps for Wayne and Monroe Counties, Lake Ontario. The coastal analysis utilized the new response base approach to map the graduated risk zones for flooding hazards.

WATER QUALITY AND WATER QUANTITY PROJECTS

Great Lakes Integrated Nearshore Framework

Client: Environment and Climate Change Canada

Project Manager for a three-year contract with Environment and Climate Change Canada to assist with the development of the Integrated Nearshore Framework and the Baseline Habitat Survey. Collectively these two components of the Great Lakes Water Quality Agreement will be used to establish a baseline assessment of nearshore water quality and habitat, upon which future improvements will be measured. The findings will be used to enhance protection of high-quality habitat and prioritize restoration activities. Community collaborations will also be supported to engage stakeholders for restoration work.

Southern Georgian Bay Beta Habitat Units

Client: Environment and Climate Change Canada

The Baseline Survey approach developed for the Habitat and Species Annex of the Great Lakes Water Quality Agreement was applied by Pete for Southern Georgian Bay. The study relied on existing lakewide geo-spatial data and the generation of new information, such as detailed wave modelling. The findings were used to map Regional Habitat Areas and nested Habitat Units.

Barbados Water Quality Study, Coastal Risk Assessment and Management Program

Client: Coastal Zone Management Unit, Government of Barbados

Project Manager for a comprehensive water quality investigation for the nearshore zone of Barbados. The study included a review of historical data, instrument deployment for new data collection, water chemistry assessment, and a detailed algae stable isotope analysis (over 500 samples) to determine the source(s) and fate of nitrogen pollution. These data were also used to develop an island wide 2D circulation model and a detailed 3D water quality model; both used to evaluate remedial alternatives to improve local water quality.

Lake Ontario – St. Lawrence River Water Level Regulation Study

Client: International Joint Commission, USACE, ECCC

Project Manager for a multi-year investigation on the impacts associated with water level regulation on Lake Ontario and the St. Lawrence River. Studies quantified the impacts on shore erosion, flooding, maintenance of existing shoreline protection structures, and supported the assessment of beach impacts and coastal dunes protecting wetlands. Economic damages were calculated with time series water levels for 3,000 km of shoreline represented by more than 20,000 individual property parcels.

International Upper Great Lakes Study

Client: ECCC, USACE, and the IJC

Managed several investigations for the Upper Great Lakes Study, including a review of available geo-spatial data, the sensitivity of the Flood and Erosion Prediction System (FEPS) to alternative regulation plans, evaluation of potential study sites, and investigation of flooding impacts associated with alternative regulation plans for historical supplies and climate change induced water supplies. The studies were used to evaluate alternative Regulation Plans for the water releases from Lake Superior.

Rainy Lake Excel Flood Tool

Client: International Joint Commission

Managed the development of a custom Excel based open source flooding tool to evaluate alternative water level regulation scenarios for the Rainy Lake system and the associated impacts on riparian property. The tool utilized time series water levels and historical storms to estimate flooding damages to existing buildings and calculate economic damages.

Preliminary Study of Structural Compensation Options for the St. Clair River

Client: International Joint Commission

Project Manager for a study into engineering options to remediate past dredging of the St. Clair River, which has increased the conveyance of the river. Conventional flow remediation structures, such as sills and weirs were considered, along with options that would enable adaptive management of flow regulation, such as gated structures and submerged hydroelectric turbines.

RESTORATION PROJECTS

Lighthouse Beach Restoration, Pictou, Nova Scotia

Client: Nova Scotia Department of Transportation and Infrastructure Renewal

Project Manager for a multi-year investigation into the breach of the Lighthouse Beach sand spit and the development of a remedial solution. Technical studies included the review of historical sand mining activities, shoreline change measurements, wave and current modelling, storm surge assessment, beach erosion simulations, and engineering design. The breach in the 1.4 km long sand spit was filled with a rock dyke and beach nourishment was used to restore the beach and dune habitat.

Ecosystem Based Adaptation Pilot Study for Reef Restoration

Client: Coastal Zone Management Unit, Government of Barbados

Managed a pilot project to restore the fringing reefs of Barbados. These shallow ecosystems protect the island beaches from storm damage and produce the carbonate sediment needed to maintain healthy beaches but have declined in response to climatic stressors and pollution. The study assessed reef health, identified coral donor colonies, and constructed an aquaculture laboratory to grow small coral in a controlled environment. Once the corals reached a sufficient size, they were transplanted to the reefs and monitored.

Keta Lagoon Causeway and Sea Defense, Ghana, West Africa

Client: Government of Ghana

Led the coastal process investigation to support the design of sea defences along a 7 km eroding barrier beach in Ghana. The long-term erosion rate ranged from 5 to 10 m/yr. Technical analysis included historical shoreline change measurements, review of geologic conditions, and littoral sediment budget calculations. The findings were used to support the remedial design, which included 10 million cubic metres of beach nourishment, a new coastal highway, land reclamation and habitat restoration.

INTERNATIONAL PROJECTS

Barbados Shoreline Change Study, Coastal Risk and Management Program

Client: Coastal Zone Management Unit, Government of Barbados

Project Manager for a shoreline change study for the island of Barbados. The investigation included the review and analysis of four decades of beach profile data to assess erosion and accretion patterns. Recommendations were provided to enhance the program with new data collection tools. Shoreline change was also analyzed with historical aerial photographs dating back to the 1950s. Detailed rates of change were calculated for the beach and cliff environments. The results were used to develop a coastal classification that characterizes the long-term shoreline trend for natural and engineering shorelines.

Development of a Hurricane Erosion Vulnerability System, Elbow Cay, Bahamas

Client: Government of The Bahamas

Lead coastal scientist for the assessment of hurricane erosion vulnerability at Elbow Cay, which was extensively damaged by Hurricane Floyd in the Fall of 1999. A custom system was developed that integrated GIS technology and numerical models to assess potential storm damage and resilience of the islands beaches to future hurricanes. The erosion prediction tools were also used to evaluate the feasibility of several remedial alternatives to strengthen the protection provided by the beaches of Elbow Cay.

Evaluation of Hurricane Impacts for a Deep-Water Outfall

Client: Government of Dominica

Investigated hurricane storm damages at the location of a proposed deep-water outfall on the Island of Dominica. The geologic properties of the site were evaluated, along with modelling estimates of beach and seabed erosion for future hurricanes. The modelling results were also used to develop the engineering aspects for the outfall, including the anchoring system and burial depth.

Simandou Port Construction Feasibility Study, Guinea

Client: Rio Tinto

Led the field investigations into the feasibility of a new port construction in a large tidal estuary in southern Guinea. The field work included instrument deployment, sediment coring and characterization within the estuary and on the delta, and a geomorphic assessment of the river shoreline and coast. The findings were used to assess navigation channel location and dredging requirements for the proposed port.

Analysis of Beach Erosion and Channel Sedimentation, Herzliya Marina

Client: Government of Herzliya

Lead coastal investigator for a beach erosion and sedimentation study at the Herzliya Marina, north of Tel Aviv. Aerial photograph comparisons, seabed change measurements, and numerical modelling were used to quantify sediment sources, rates of sediment transport, and channel sedimentation. Remedial options were developed to reduce future maintenance costs and maintain safe navigation into the marina basin.

TECHNICAL PAPERS AND CONFERENCE PRESENTATIONS

Zuzek, P.J. (2019). Flood and Erosion Vulnerability Studies in Southwestern Ontario. Southwestern Ontario Shoreline Roundtable Information Meeting, London, Ontario

Zuzek, P.J. (2019). Chatham-Kent Lake Erie Shoreline Study and Planning Implications. 2019 Ontario West Planners Forum, London, Ontario.

Zuzek, P.J. (2019). Climate Change Impacts on Coastal Storms and Ice Cover for Lakes Erie and Ontario. Provincial Flood Forecasting and Warning Workshop, Toronto, Ontario.

Zuzek, P.J. (2018). Collaborative Shoreline Management Planning and Climate Change Adaptation Planning on Lake Erie. Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J. and Mortsch, L. (2018). Adapting to the Future Storm and Ice Regime in the Great Lakes. Coastal Zone Canada Association Conference, St. John's, Newfoundland.

Zuzek, P.J., Anderson, J., McKenna, J., and Hatcher, J. (2018). Application of the Nearshore Framework Assessment for Lake Erie and the Huron-Erie Corridor in Canada. International Association of Great Lakes Research Conference, Toronto, Ontario.

Zuzek, P.J. (2017). Overview of Coastal Hazard Management in the Great Lakes. Eight Annual National Roundtable on Disaster Risk Reduction, Halifax, Nova Scotia.

Zuzek, P.J. (2016). Elgin County Shoreline Management Plan. Proceedings of the 2016 Coastal Zone Canada Conference, Toronto, Ontario.

Degia, K. and Zuzek, P.J. (2016). Coral Reef Restoration as a Climate Change Adaptation Approach. Proceedings of the 2016 Coastal Zone Canada Conference, Toronto, Ontario.

Zuzek, P.J. (2015). Development of a Joint Shoreline Management Plan for Elgin County. Proceedings of the 2015 Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J. (2014). Development of an Integrated Nearshore Framework for the Great Lakes. Proceedings of the Coastal Zone Canada 2014 Conference, Halifax, Nova Scotia.

Zuzek, P.J. (2013). Stakeholder Engagement and Initial Development of the Great Lakes Nearshore Framework. Proceedings of the Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J. (2012). Developing a Long-term Shoreline Management Plan for Victoria Beach Using a Stakeholder Centric Framework. Coastal Zone Canada Conference 2012, Rimouski, Quebec.

Zuzek, P.J. (2011). The Integration Imperative for Sustainable Coastal Management. Proceedings of the Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J. (2011). Pilot Studies to Evaluate the Draft 2009 Guidelines and Specifications for Coastal Floodplain Mapping in the Great Lakes Basin (Event vs. Response Methods). Association of State Floodplain Managers, Louisville, Kentucky.

Zuzek, P.J., Craig, B., Dobbie, T., and McKay, V. (2010). Application of Ecosystem Based Management Principles to the Design of Erosion Mitigation Alternatives for PPNP. Proceedings of the Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J. (2010). Nova Scotia Coastal Infrastructure Risk Assessment: Applying Sound Planning and Engineering to Reduce Risk and Lower Maintenance Costs Along Coastal Highways in Nova Scotia. Proceedings of the 2010 Coastal Zone Canada Associate Conference, Charlottetown, PEI.

Zuzek, P.J. (2009). Great Lakes Climate Change and Policy Workshop for the Coastal Zone. Proceedings of the Latornell Conservation Symposium, Alliston, Ontario.

Zuzek, P.J., Schmidt, K., Henderson, J., and Craig, B. (2008). Sustainable Management Strategy for Southeast Leamington, Ontario, Canada. Proceedings of the 2008 Coastal Zone Canada Association Conference.

Nairn, R.B., Zuzek, P.J., Charles, M., and Moir, C. (2008). Restoration of Lighthouse Beach Sand Spit, Pictou Landing, Nova Scotia. Proceedings of the 2008 Coastal Zone Canada Association Conference.

Nairn, R.B., Zuzek, P.J., and Woodrow, D. (2007). Evolution and Future of the Eastern Lake Ontario Dunes and Barrier Beaches. Proceedings of the International Associations of Great Lakes Research Conference 2007.

Zuzek, P.J. (2007). Will There Be Beaches on Lake Ontario for the 100th IAGLR Conference? Proceedings of the International Associations of Great Lakes Research Conference 2007.

Zuzek, P.J., Schmidt, K., and Craig, B. (2007). Developing a Sustainable Management Strategy for Southeast Leamington: A Multi-Agency and Stakeholder Collaboration Across Boundaries. Proceedings of the 6th International Science and Management of Protected Areas Association (SAMPAA) Conference. May 21-26, 2007, Wolfville, NS.

Nairn, R.B. and Zuzek, P.J. (2006). Automated Lake-wide Calculations of Coastal Erosion and Economic Damages for Lake Ontario. Proceedings of the 59th CWRA Annual Conference. June 4-7, Toronto, Ontario.

Zuzek, P.J. Bender, T. and Moulton, R. (2005). Development of a Comprehensive GIS Parcel Database for the Coastal Hazard Zone of Lake Ontario. Proceedings of the Coastal Geotools Conference, 2005, Myrtle Beach, S.C.

Zuzek, P.J. and Nairn, R.B. (2005). Automated Lake-wide Calculations of Coastal Flooding and Economic Damages for Lake Ontario. Proceedings of the Coastal Disasters Conference, 2005, Charleston, SC.

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Langendyk, S., Zuzek, P.J. and Penner, L (2005). Visualization and Knowledge Transfer for Gull Lake Erosion Modelling using ARCpublisher and ARCreader. Proceedings of the Coastal Geotools Conference, 2005, Myrtle Beach, S.C.

Scott. D, Schwab, D, Zuzek, P. and Padala, C. (2004). Hindcasting Wave Conditions on the North American Great Lakes. Proceedings of the 8th International Workshop on Wave Hindcasting and Forecasting, Hawaii. November 14-19, 2004.

Zuzek, P.J., R.D. Scott, P. Chittibabu and T.S. Murty (2003). A Review of Wave Regime in Lake Ontario in View of Climate Change. Proc. of Canadian Coastal Conference – 2003, Queen's University, Kingston, Ontario, Canada.

Zuzek, P.J., Nairn, R.B., Elliott, T. and Moulton, R. (2003). Erosion Modelling and Economic Damage Calculations with the Flood and Erosion Prediction System, IJC Lake Ontario – St. Lawrence River Study. Canadian Coastal Conference 2003, Kingston, Ontario.

Zuzek, P.J., Nairn, R.B. and Thieme, S.J. (2003). Spatial and Temporal Considerations for Calculating Shoreline Change Rates in the Great Lakes Basin. Journal of Coastal Research, Special Issue No. 38, 2003. pp 125-146.

Zuzek, P.J., Nairn, R.B. and Ross, P. (2003). Quantifying the Historic Nearshore Sediment Budget for Ottawa and Allegan County, Lake Michigan – 1860 to Present. Proceedings of the International Associations of Great Lakes Research Conference 2003.

Zuzek, P.J., Bender, T. and Moulton, R. (2003). Integration of Geo-Spatial Layers, Economic Data, and Custom Modelling Tools to quantify Coastal Hazards and Economic Damages on Lake Ontario and the St. Lawrence River. Proceedings of the Coastal Geotools Conference 2003, Charlestown, S.C.

Marván, F.G., Nairn, R.B. and Zuzek, P.J. (2003). FEPS (Flood and Erosion Prediction System), a tool for evaluating Shoreline Processes and their Economic Impacts and its Potential Application to the Texas Coast. Proceedings of the Texas GLO Conference, 2003.

Elliott, T., Zuzek, P., Nairn, R.B. and Bender, T. (2003). The IJC Lake Ontario – St. Lawrence River Study, An Overview of Selected Coastal Technical Working Group Activities on the Lake and Upper River. Proc. CSCE 1st Coastal, Estuary and Offshore Engineering Conference.

Zuzek, P.J. and Nairn, R.B. (2002). Quantifying Climate Change Impacts on Coastal Evolution: Application of the Flood and Erosion Prediction System (FEPS). Proceedings of the Coastal Disasters Conference 2002, San Diego, CA.

Zuzek, P.J. (2002). New Tools and Techniques for Shoreline Change Estimation in the Great Lakes Basin. Proceedings of the Shoreline Change Conference May 7-9. Charleston, SC.

Zuzek, P.J. and Nairn, R.B. (2001). Application of the Flood and Erosion Prediction System in Ottawa and Allegan Counties, Michigan. Proceedings of the Lake Michigan State of the Lake Conference, Muskegon, Michigan.

Zuzek, P.J., Nairn, R.B., and Langendyk, S.L. (2001). Lake Michigan Potential Damages Study: Part 1. Proceedings of the Coastal Geotools Conference, Charleston, South Carolina.

Zuzek, P.J. and Nairn, R.B. (2001). Predicting Shoreline Erosion with Numerical Models and Custom GIS Tools. Proceedings of the Coastal Zone Conference, Cleveland, Ohio.

Zuzek, P.J., Nairn, R.B. and Gauthier, R.L. (2001). Spatial and Temporal Variability in Top of Bank Erosion Rates: Lessons Learned from the Lake Michigan Potential Damages Study. Proceedings of the International Associations of Great Lakes Research Conference 2001.

MacIntosh, K., Scott, R.D., Zuzek, P.J., and Langendyk, S.L. (2001). Development of a GIS Based Hurricane Vulnerability Assessment System for Elbow Cay, Bahamas. Proceedings of the Coastal Geotools Conference, Charleston, South Carolina.

Zuzek, P.J., Nairn, R.B., and Langendyk, S.L. (2000). A GIS Linked Flood and Erosion Prediction System for the Great Lakes. Proceedings of the International Association of Great Lakes Research Conference, Cornwall, Ontario.

Zuzek, P.J., Nairn, R.B., Gauthier, R.L., and Thieme, S.J. (1999). A GIS-Linked Shore Erosion Prediction System for Lake Michigan. Proceedings of the Coastal Geotools Conference, Charleston, South Carolina.

Zuzek, P.J., Mattie, B., Latimer, B., and Porter, G. (1998). Keltic Lodge Coastal Erosion Study. Proceedings of the Canadian Coastal Conference, Vancouver, British Columbia.

Nairn, R.B. and Zuzek, P.J. (1999). Coastal Processes and Erosion on Lake Erie at the Millennium. Proceedings of the Lake Erie at the Millennium Conference, Windsor, Ontario.

Zuzek, P.J., Nairn, R.B., and Minns, C.K. (1997). The Physical Assessment of Developments Affecting Fish Habitat in Great Lakes Nearshore Regions. Proceedings of the Canadian Coastal Conference, Guelph, Ontario.

Nairn, R.B., Zuzek, P.J., Morang, A., and Parson, L. (1997). Effectiveness of Beach Nourishment on Cohesive Shores, St. Joseph, Lake Michigan. Technical Report CHL-97-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nairn, R.B., Scott, R.D., Anglin, C.D. and Zuzek, P.J. (1994). Analysis of Coastal Processes at Toronto Islands. Proceedings of the 24th International Conference on Coastal Engineering, ASCE, Japan.

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PERSONAL INFORMATION

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EDUCATION AND DEGREES

1992 PhD Geography, McMaster University, Hamilton, Ontario. Thesis title: The Development of Stratification of Vegetated Coastal Sand Dunes, Sable Island, Nova Scotia. Supervisor: Dr. Brian McCann

1986 MSc Geography, McMaster University, Hamilton, Ontario. Thesis title: The morphology and sedimentology of vegetated Canadian coastal sand dunes. Supervisor: Dr. Brian McCann

1984 BA Honours, (1st class) Geography in Resource Management, University of Windsor, Windsor, Ontario. Thesis title: The effect of Holocene sea level changes on rock coasts. Supervisor: Dr. Alan Trenhaile

ACADEMIC EMPLOYMENT HISTORY

- July 2016 to present – Geography and Environmental Studies, Wilfrid Laurier University, Professor
- July 1999 to June 2016 – Geography and Environmental Studies, Wilfrid Laurier University, Associate Professor
- July 1991 to July 1999 - Geography and Environmental Studies, Wilfrid Laurier University, Assistant Professor

- July 1990-91 **Lab Instructor**, Department of Geography, McMaster University, Hamilton, ON.

HONOURS AND AWARDS

- Faculty Award for Service Excellence and Community Engagement (2020).
- President's Award for Outstanding Service, Canadian Association of Geographers, Inaugural Recipient (2011).
- Wilfrid Laurier University Award for Teaching Excellence (2008).

RESEARCH AND PUBLICATIONS

LABORATORY AND FIELD EXPERIENCE

2013 to 2016	Reviewing and documenting the geomorphic history of Sable Island, Nova Scotia
2012 to present	Analyzing environmental impact of informal trails networks at Pinery Provincial Park
2009 to present	Dune habitat rehabilitation, Point Pelee National Park
2004 to 2012	Monitoring sediment transport at Sandbanks Provincial Park.
1998 to 2012	Examining nearshore processes at Presquile Provincial Park.
1995 - 2001	GIS analysis of coastal slope failures on north shore Lake Erie, GIS analysis of Natural Areas Connectivity, Algonquin Lake Plain and the shores of Lake Huron.
1993 to 2011	Researching seasonal sediment transport variations at Pinery Provincial Park.
1992 Field	Research on Les Iles De La Madeleine, Quebec, examining the internal structures of parabolic sand dunes.
1989 Field	Research with Dr. S.B. McCann on Tracadie Spit on the North Shore of Prince Edward Island, examining internal structures within forested coastal dunes.
1984	Atmospheric Environment Service, Canada Climate Centre. Collected data on the national climate system and created a data base for the Station Information System.
1982-83	Laboratory assistant to Dr. A.S. Trenhaile preparing rock cores for pore water content experiments. Researching effects of Holocene sea level fluctuations on rock coasts.

RESEARCH FUNDING

June 2006	Human Resources and Development Canada, Summer Career Placement program, $1494
June 2005	Human Resources and Development Canada, Summer Career Placement program, $1398.75
April 2005 to	Presquile Provincial Park, Beach Mapping Research contract, $2,773.55
March 2005	Sandbanks Provincial Park, Research contract for Geomorphological inventory, $4,000.
May 2000 - Nov. 2001	Presquile Provincial Park Research Contract, Monitoring dune growth on North Beach, $2,000.
June 2000	Human Resources and Development Canada, Summer Career Placement program, $1200

Jan.-Dec. 2000 Ontario Parks Research Grant, Monitoring Sand Transport at Pinery Provincial Park, $3,000.

May 1999 – May 2000 Presquile Provincial Park Cladophora in the nearshore Support in kind for accommodation and research assistant, $5,000

June'98 - June 1999 WLU Short Term Research Grant to examine structures in the lee face of a trough blowout at Pinery Provincial Park, $2500.

June1995 - June 1997 Support-In-Kind from Killbear Provincial Park. Support is equivalent to the entrance to the park and accommodation and office support for a graduate student (Kathryn Parlee) in her field investigation. This support is equivalent to approximately $5000.00.

June 1994 - June 1995 WLU Short Term Research Grant to examine parabolic dune orientation at Pinery Provincial Park, $2500.

May 1993 - May 1994 WLU Short Term Research Grant to study coastal dunes at Pinery Provincial Park, $2500

Summer 1992 WLU PDRF to study dunes in Les Iles de la Madeleine, P.Q. $2500.

Summer 1992 WLU Short Term Research Grant to study dunes in Les Iles de la Madeleine, $2500.

TEXTBOOKS AND MANUALS

Robert W. Christopherson, Ginger Birkeland, **Mary-Louise Byrne**, and Philip Giles; GEOSYSTEMS An introduction to physical geography, Fourth Canadian Edition. Pearson Prentice Hall, Toronto, 2016.

Robert W. Christopherson, **Mary-Louise Byrne**, and Philip Giles; GEOSYSTEMS An introduction to physical geography, Third Canadian Edition. Pearson Prentice Hall, Toronto, 2013.

Robert W. Christopherson and **Mary-Louise Byrne**, Canadian GEOSYSTEMS An introduction to physical geography. Pearson Prentice Hall, Toronto, 2009.

Robert W. Christopherson and **Mary-Louise Byrne**, GEOSYSTEMS An introduction to physical geography, First Canadian Edition. Pearson Prentice Hall, Toronto, 2006.

R.W. Christopherson, C.E.Thompson, M.-L.Byrne, Instructors Resource Manual, Canadian GEOSYSTEMS An introduction to physical geography, Fourth Edition. Pearson Prentice Hall, Toronto.2015.

R.W. Christopherson, C.E.Thompson, **M.-L.Byrne**, Instructors Resource Manual, Canadian GEOSYSTEMS An introduction to physical geography, Third Edition. Pearson Prentice Hall, Toronto.2013.

R.W. Christopherson, C.E.Thompson, **M.-L.Byrne**, Instructors Resource Manual, Canadian GEOSYSTEMS An introduction to physical geography, Second Edition. Pearson Prentice Hall, Toronto.2009.

R.W. Christopherson, C.E.Thompson, **M.-L.Byrne**, Instructors Resource Manual, GEOSYSTEMS An introduction to physical geography, First Canadian Edition. Pearson Prentice Hall, Toronto.2006.

EDITED BOOKS AND JOURNALS

Bill Freedman and **Mary-Louise Byrne**. 2016: Historic Observations and Uses of Sable Island. In: Freedman, B. (Ed.) Sable Island Explorations in Ecology & Biodiversity.Fitzhenry and Whiteside, Toronto, p1-16.

Mary-Louise Byrne, Bill Freedman and David Colville. 2016. The Geology of Sable Island and Evolution of the Sable Island Bank. In: Freedman, B. (Ed.). Sable Island Explorations in Ecology & Biodiversity. Fitzhenry and Whiteside, Toronto, p 17-34.

Bill Freedman, Zoe Lucas and **Mary-Louise Byrne**. 2014. Historic Use and Observations of Sable Island. In: Freedman, B. (Ed.). *An Ecological and Biodiversity Assessment of Sable Island*. Report prepared for Parks Canada, Halifax, NS.

Mary-Louise Byrne, Bill Freedman and David Colville. 2014. The Geology of Sable Island and Evolution of the Sable Island Bank. In: Freedman, B. (Ed.). *An Ecological and Biodiversity Assessment of Sable Island*. Report prepared for Parks Canada, Halifax, NS.

Byrne, M.-L. 2010: Great Lakes (USA).In Encyclopedia of World's Coastal Landforms Volume I. Eric C. F. Bird (Ed). Springer, pp 121-124.

Byrne, M.-L. 2010: Great Lakes (Canada).In Encyclopedia of World's Coastal Landforms Volume I. Eric C. F. Bird (Ed). Springer, pp 177-182.

Byrne, M.-L. (Ed.) 2006. Coastal and Northern Processes, Landforms, and Sediments: Brian McCann's influence on geomorphology in Canada. Geographie Physique et Quaternaire, vol. 60, no1, Special Publication, 92 pp.

Joseph R. Desloges, Roger T.J. Phillips, Mary-Louise **Byrne** and Jackie Cockburn, 2020. Geomorphology of the Great Lakes Lowlands – Eastern Canada. *In* Slaymaker O, Catto N (eds) Landscapes and Landforms of Eastern Canada. Springer International Publishing, Switzerland.

Hewitt, K, English, **M. Byrne**, M-L. and Young, G, (Eds.) 2002. Landform assemblages and transitions in cold regions: Proceedings of the International Symposium, CRRC, WLU For Kluwer Scientific Publishers, Geojournal Monographs.

REFEREED JOURNAL PUBLICATIONS

Abdullah BaMasoud and **Mary-Louise** Byrne, 2013: The predictive accuracy of shoreline change rate methods on Point Pelee Ontario (1931-2008). Journal of Great Lakes Research Volume 39, Issue 1, March 2013, Pages 173–181. (Article featured in IAGLR news release)

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 Volumes 173-174, pp.141–148.

BaMasoud, A. and **Byrne, M.-L.** 2011. Analysis of Shoreline Changes (1959–2004) in Point Pelee National Park, Canada. Journal of Coastal Research: Volume 27, Issue 5: pp. 839 – 846.

Byrne, M-L. and D. Lamothe, 1999. A Comparison of Shoreline Management Policy Applications in Essex County, Ontario. The Great Lakes Geographer 5, 1-14.

Byrne, M-L. 1997. Seasonal Sand Transport through a Trough Blowout at Pinery Provincial Park, Ontario. Canadian Journal of Earth Science. Vol. 34, 1460-1466.

Byrne, M-L. and S.B. McCann, 1995. The Dunescape of Sable Island. The Canadian Geographer Vol. 39, No. 4, 363-368.

McCann, S.B., and **Byrne, M.-L.** 1994. Dune morphology and the evolution of Sable Island, Nova Scotia. Physical Geography, Vol. 15, no.4, 342-357.

Byrne, M.-L. and McCann, S.B., 1993. The Internal Structure of Vegetated Coastal Sand Dunes, Sable Island, Nova Scotia. Sedimentary Geology 84, 199-218.

Byrne, M.-L. and McCann, S.B. 1990. Stratification and sedimentation in complex vegetated coastal dunes, Sable Island, Nova Scotia. Sedimentary Geology 66, 165-179.

Juan Felipe Gómez, **Mary-Louise Byrne**, James Hamilton, and Federico Islas. 2017: Historical Coastal Evolution and Dune Vegetation in Isla Salamanca National Park, Colombia. Journal of Coastal Research 33, 632-641.

McCann, S.B. and **Byrne, M.-L.** 1989. Stratification models for vegetated coastal dunes in Atlantic Canada. Proceedings of the Royal Society of Edinburgh, 96B, 203-215.

Nayak, P.M. and M. L. Byrne, 2019. Impact of land use land cover change on a sand dune ecosystem in Northwest Beach, Point Pelee National Park, Canada, Journal of Great Lakes Research, https://doi.org/10.1016/j.jglr.2019.10.003; Volume 45, Issue 6, pp. 1047-1054.

Trenhaile, A.S. and **Byrne, M.-L.** 1986. A theoretical investigation of the Holocene development of rock coasts with particular reference to shore platforms. Geografiska Annaler 68 A (1- 2), 1-14.

REFEREED CONFERENCE PROCEEDINGS

BaMasoud, Abdullah and **M.-L. Byrne**, 2007. Shoreline changes analysis in Point Pelee National Park, Ontario, Canada (1959-2004). Proceedings of Coastal Zone 07, Portland Oregon, p 1-5.

Byrne, M-L, Woods, D. and Maclean, A. 2003. Water level changes and sand transport at Pinery

Provincial Park: longterm dune development implications. Proceedings of the Parks Research Forum of Ontario (PRFO) Annual Meeting, p 133-142.

Byrne, M-L. and Dionne, J-C. 2002. Typical aspects of cold regions shorelines. In Hewitt et. al (eds.) Landform assemblages and transitions in cold regions: Proceedings of the International Symposium, CRRC, WLU For Kluwer Scientific Publishers, Geojournal Monographs, p. 141-158.

Bitton, M. and **Byrne, M-L.** 2002. A Volumetric Analysis of the Changing Morphology of a Coastal Dune Blowout, Pinery Provincial Park, Ontario. Proceedings of the Parks Research Forum of Ontario (PRFO) Annual Meeting, p. 221-230.

Byrne, M-L. and Bitton, M. 2001. Sand transport and water level change at Pinery Provincial Park, Ontario. In Ecological Integrity and Protected Areas. Proceedings of the Parks Research Forum of Ontario (PRFO) Annual Meeting, p. 225-235.

Byrne, M.-L. 1990. Stratigraphic signatures of plant communities in coastal sand dunes, Sable Island, Nova Scotia. Proceedings, Symposium on Coastal Sand Dunes, Guelph, 1990. NRC Associate Committee on Shorelines.

Non-Refereed Contributions

Byrne, M-L., Janis Dale, and Abdullah BaMasoud, 2013: A study to characterize the dune forming processes at Northwest Beach in Point Pelee National Park in Ontario. Submitted to Park office August, 2013, Leamington, ON.

Byrne, M.-L. 2001: Photographs displaying sand dune dynamics, Prince Edward Island National Park, Interpretive Centre, St. Peters, Prince Edward Island. Opened to public view, May 2001.

Byrne, M.-L. and Kathryn Parlee, 1997: “Please Don’t Ruin the Dune” An Examination of Dune Development at Killbear Provincial Park. A report on research in Killbear Provincial Park submitted to the Park Office April 1997, Parry Sound, ON.

PROFESSIONAL ORGANIZATIONS AND MEMBERSHIPS

Current Professional Memberships:

Association of Professional Geoscientists of Ontario
Canadian Association of Geographers
Canadian Federation of Earth Scientists
Coastal Education Research Foundation
Association of American Geographers
Geological Society of America
Geological Association of Canada
Canadian Geomorphology Research Group
Geographic Education Study Group (CAG)
Society for Teaching and Learning in Higher Education (STLHE)

APPENDIX B

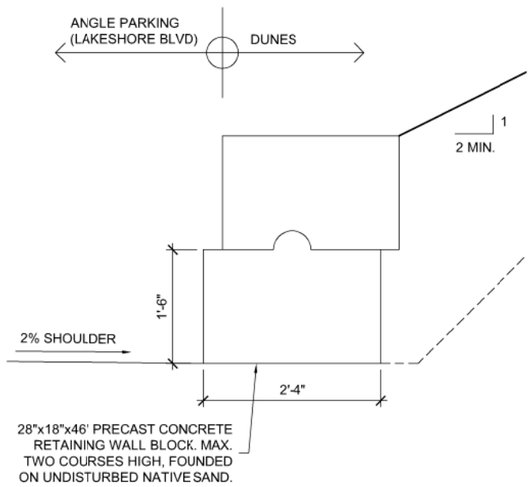
BluePlan Engineering Design

SEGMENTAL RETAINING WALL STRUCTURAL NOTES:

1. ALL BLOCKS SHALL BE PRECAST CONCRETE BLOCKS AS MANUFACTURED BY REDI-ROCK.
2. BEFORE PROCEEDING WITH WORK, CHECK ALL THE DIMENSIONS SHOWN ON THE DRAWINGS AND REPORT ANY DISCREPANCIES TO THE ENGINEER.
3. STRUCTURAL DESIGN HAS BEEN COMPLETED IN ACCORDANCE WITH DIV. B, PART 4 OF THE 2012 ONTARIO BUILDING CODE.
4. PLACE RETAINING WALL ON COMPETENT NATIVE SOIL CAPABLE OF SUSTAINING AN ALLOWABLE SOIL BEARING CAPACITY OF 100 kPa (2000 psf).
5. UPON EXCAVATION AND PRIOR TO PLACING WALL, ALL DESIGN INFORMATION INDICATED SHALL BE VERIFIED BY AN ENGINEER TO ENSURE ASSUMED SOIL CONDITIONS ARE MET OR EXCEEDED.
6. PLACE GEOTEXTILE BEHIND WALL PRIOR TO BACKFILLING WITH DUNE SAND.
7. RETAINING WALL TO BE CONSTRUCTED IN A RUNNING BOND PATTERN (IE. STAGGER JOINTS).
8. DESIGN INFORMATION:

UNIT WEIGHT OF SOIL, y:	16.5 kN/m³ (pcf)
UNIT WEIGHT OF CONCRETE BLOCK, y:	24 kN/m³ (pcf)
SURCHARGE LOAD:	Not Considered
SOIL FRICTION ANGLE, Ø:	30°
COULOMB ACTIVE EARTH PRESSURE, Ka:	0.494

9. LAYOUT OF WALL BY OTHERS.



RETAINING WALL SECTION
SCALE: ½"=1'-0"

SAUBLE BEACH, ONT.
KEY PLAN
SCALE: N.T.S.

Approved Grey Sauble Conservation Authoirty
Permit #GS20-363
Nov. 20, 2020 A.S.

NO.	DATE	REVISION DESCRIPTION	CH'KD
1	NOV 9, 2020	ISSUED FOR REVIEW	B.A.W.

LICENSED PROFESSIONAL ENGINEER
Nov 9/20
B. A. WILLIS
PROVINCE OF ONTARIO
STRUCTURAL ONLY

RETAINING WALL
LAKESHORE BLVD,
SAUBLE BEACH
TOWN OF SOUTH
BRUCE PENINSULA
NOTES AND SECTION

BluePlan ENGINEERING

DRAWN BY :	APPROVED BY :	PROJECT NO. :	DRAWING NO. :
C.B.	B.A.W.	220359	1
DESIGNED BY :	DATE :	SCALE :	
B.A.W.	NOV. 9, 2020	1/2"=1'-0"	