2017-03-30 DRAFT REPORT

Flooding and Dynamic Beach Hazard Delineation
Town of Wasaga Beach

Nottawasaga Valley Conservation Authority

Lake Simcoe/South-eastern Georgian Bay Clean-up Fund

prepared by

Shoreplan
Engineering Limited

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SHOREPLAN

LSSEGBCUF Flood and Dynamic Beach Hazard Delineation
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Prepared for

Nottawasaga Valley Conservation Authority

by

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1. INTRODUCTION

The Nottawasaga Valley Conservation Authority (NVCA) is updating their natural hazard, nearshore bathymetry, and biodiversity mapping for the Georgian Bay shoreline of the Towns of Wasaga Beach and Collingwood. This project, which is funded by Environment Canada's Lake Simcoe/South-eastern Georgian Bay Clean-up Fund (LSSEGBCUF), will provide detailed physical and environmental data along the Georgian Bay shoreline to NVCA, The Town of Wasaga Beach, the Town of Collingwood, and other stakeholders. This information is critical to agencies responsible for managing recreation and development while protecting the ecological integrity of the coastal area.

This report describes Shoreplan Engineering's contribution to that work for the Town of Wasaga Beach. We delineated two natural hazard limits, the flooding hazard and the dynamic beach hazard, using updated bathymetric and topographic survey data collected by other project team members. Natural hazards are defined in Section 3.1 of the Provincial Policy Statement (PPS). Development within the study area on lands affected by these natural hazards is subject to approval under Ontario Regulation 172/06, which is administered by NVCA.

1.1. Study Area

Figure 1.1 is a location plan showing the Simcoe County municipalities along Southeastern Georgian Bay. The study area includes all of the Georgian Bay shoreline within the Town of Wasaga Beach. For ease of reference we treat the entire Wasaga Beach shoreline as being oriented in an east-west direction, so the Tiny town line is treated as the eastern limit of the study area and the Collingwood town line is treated as the western limit of the study area.

1.2. Report Format

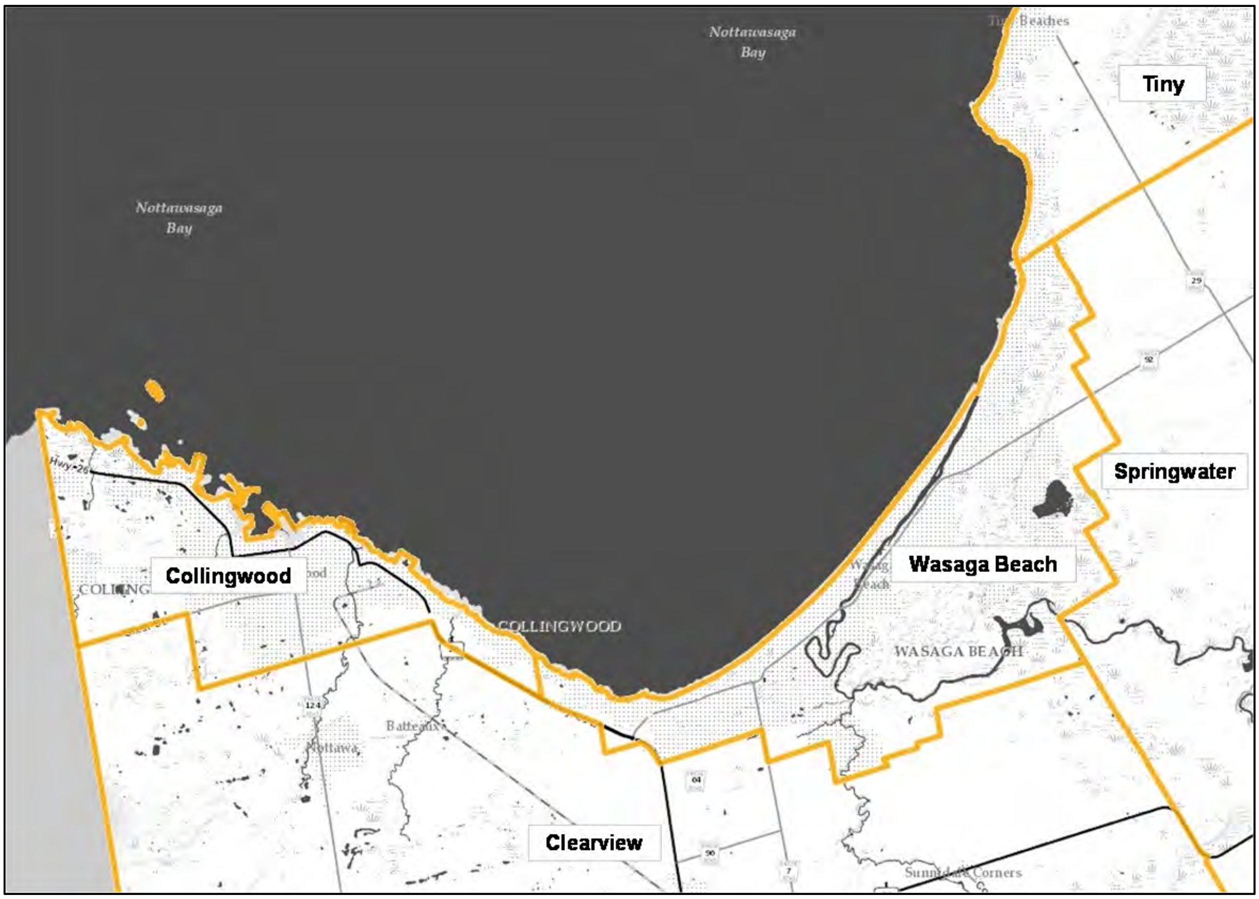
The report consists of 5 chapters, each divided into a number of sections. The first chapter is this introduction. The second chapter provides a brief summary of our field review. Chapters three and four describe the hazard delineation, hazard mapping, and application of the hazard information for the flooding and dynamic beach hazards, respectively. Chapter five presents a summary and conclusions.

Figures are located at the end of the chapter in which they are first mentioned and reference the chapter in the first digit of the figure number. Tables are included in the text body and use a similar numbering format. A list of tables and a list of figures are included in the Table of Contents.

1.3. NVCA Supplied Data

Data collected by other participants in the LSSEGBCUF program was provided by NVCA for use in this study. That data included 10cm resolution orthorectified aerial photographs as well as a combined bathymetric and topographic data set that contained onshore and offshore elevations on a 5m by 5m grid. The data bathymetric/topographic data extended from approximately the 171m contour offshore, to well inland of the wave uprush and dynamic beach hazard limits defined by this study.

Figure 1.1 Project Area Location Plan



from Simcoe County interactive mapping

2. FIELD REVIEW

A field review was conducted to document existing conditions along the shoreline, including the presence of protection structures that might impact the dynamic beach hazard limit. The shoreline was walked late October and early November, 2016, and was documented with both field notes and photographs. Digital copies of selected photographs from our review are provided under separate cover. A list of the coordinates of each photograph is presented in Appendix A.

One purpose of the field review was to identify the lateral limits of the dynamic beach segments. More than eighty per cent of the Wasaga Beach shoreline is classified as a dynamic beach, extending from the eastern Town limit to 74th Street North, excluding a short portion between 70th Street North and the end of Bay Street. The exact limits of the dynamic beach hazard as defined by this study can be determined from the shapefiles described in Section 4.1. How the dynamic beaches were defined and how that definition relates to nearshore coastal processes is described in Section 4.

The beach is also interrupted by the outlet of the Nottawasaga River, but we consider the dynamic beach classification to be continuous through that area. The riverfront properties including, and west of, 36 Hiawatha Ave do not have dynamic beach shorelines because they are on the south side of the river, but there is a dynamic beach on the north side of the river, between those properties and Nottawasaga Bay.

3. FLOODING HAZARD

The 2014 Provincial Policy Statement defines the flooding hazard along the Great Lakes shoreline as the 100-year flood level plus an allowance for wave uprush and other water related hazards. Figure 3.1 is a sketch from MNR (2001) showing the flooding hazard limit. Other water related hazards include ship generated waves and flooding caused by ice related issues. Neither of those conditions applies at within the study area.

The 100-year flood level is defined as the peak instantaneous still water level, resulting from combinations of mean monthly lake levels and wind setups, which has a 1% chance of being equaled or exceeded in any given year. This is a statistical water level that accounts for both long term and short term water level fluctuations, but does not account for storm wave action.

MNR (1989) calculated instantaneous water levels for all Canadian shores on the Great Lakes using a combined probability analysis of monthly mean lake levels and storm surges. Table 3.1 shows the calculated water levels for different return periods for the shoreline sector including Wasaga Beach. The 100-year flood level for Wasaga Beach is 178.0 metres.

Table 3.1 MNR (1989) Design Water Levels for Wasaga Beach

Return Period (years)	2	5	10	25	50	100
Instantaneous Water Level (metres, GSC)	177.19	177.49	177.65	177.81	177.91	178.00
Highest Annual Monthly Water Level (m GSC)	176.67	176.96	177.11	177.26	177.36	177.44
Wind Set Up, Wind Surges (metres)	0.50	0.61	0.68	0.78	0.85	0.93

MNR (2001) recommends that the wave uprush component of the flooding hazard be determined for a 20-year storm event occurring at the 100-year instantaneous water level. The 20-year storm event has a deep-water significant wave height of 5.3m, a peak wave period of 10 seconds, and originates from the northwest. This was determined from a peak-over-threshold extreme value analysis of storm events selected from a 56-year database of hindcast hourly wave conditions.

The significant wave height is a statistical representation of the random wave heights that occur over a given period of time (hourly in this instance) and is defined as the average of the highest 1/3 of the wave heights that occur over that period. It is the most commonly used definition of a wave condition, although other statistical representations are also used. The 2% exceedance wave height, which is the wave height equalled or exceeded two per cent of the time, is also used in uprush calculations. Figure 3.2 shows the significant wave height and the 2% exceedance wave height as a function of the distance offshore for a typical profile on Wasaga Beach. The significant wave height and the 2% exceedance wave height converge as the water depth decreases due to wave breaking processes.

Wave conditions along the shoreline were determined using the CMS-Wave numerical model developed by the U.S. Army Corps of Engineers (Lin et al, 2008). CMS-Wave is a two-dimensional spectral wave model with energy dissipation and diffraction terms. It simulates a steady-state spectral transformation of directional random waves co-existing with ambient currents in the coastal zone. It includes features such as wave generation, wave reflection, bottom frictional dissipation, wave uprush and overtopping. Nearshore bathymetry in the wave model was derived from the composite bathymetry/topographic data set supplied by NVCA. Bathymetry offshore of the NVCA data was obtained from Canadian Hydrographic Service field sheets. A coarse bathymetric grid was extended from the study site out to deep water. A series of finer nested grids were used to cover the area from about the 6m depth contour up to the limit of wave uprush.

Wave uprush limits throughout the study area were determined from a combination of CMS-Wave model results and the results of an in-house program for applying wave uprush equations on composite slope profiles. Uprush is the maximum shoreward wave swash on structures and beaches and is caused by waves breaking in the nearshore. It has two components: the rise of the mean water level by wave breaking (wave setup), and the swash of incident waves. The swash oscillation of incident natural waves is a random process and the 2% exceedance of all vertical levels, denoted as R2%, is frequently used to define the maximum uprush elevation.

The wave uprush limit was initially modelled with CMS-Wave. Lin et al (2008) found that the 2% swash exceedance level could be approximated by the local wave setup on structures and beach faces. The wave uprush algorithm in CMS-Wave was tested by computing approximately 400 random wave conditions considered during physical model tests carried out by Ahrens and Titus (1981) and Mase and Iwagaki (1984). Figure 3.3 shows the measured versus the CMS-Wave-calculated 2% exceedance wave uprush for those experiments. The calculated uprush was considered to correlate well with the measured values for all test slopes. The mean bias of calculated uprush was generally small in all cases except for the steepest slope (1:1) condition in which CMS-Wave tended to overestimate the uprush (Lin et al, 2008). As overestimation of the uprush leads to conservative flooding hazard limits, it was considered to be acceptable for this study. By using a fine shore-normal grid resolution the zero contour of the local wave setup can be plotted as the limit of wave uprush. The nested grids used in this application had a shore-normal grid size of 1.0 metres.

The CMS 2D model sometimes yields solutions in adjacent (shore normal) grid cells, which requires some interpretation of the model results. That interpretation was completed using the results of 1D wave uprush calculations completed using an in-house program for applying wave uprush equations on composite slope profiles. With the composite slope procedure, the uprush limit associated with the 2% exceedance wave height is first calculated at the outer end of the profile. The program then calculates the uprush from progressively smaller breaking wave heights moving landward through the surf zone. At each step an uprush solution is iterated for an equivalent straight line slope acting over the section of the profile between the break point and the limit of wave uprush. The wave uprush limit is determined from the greatest landward incursion of the different uprush solutions. The wave height that produces this limiting uprush is frequently smaller than the initial wave height due to the changing slopes over the profile. A smaller wave breaking on a steeper section of slope can cause greater uprush than a larger wave breaking further offshore over a flatter composite slope.

3.1. Mapping the Flooding Hazard Limit

The limit of wave uprush, calculated as described above, defines the flooding hazard for the study area. The flooding hazard limit was digitally mapped and provided to NVCA as a GIS shapefile. Figure 3.4 shows an example of the flooding hazard limit superimposed on the provided orthorectified aerial photographs. It also shows the 178.0m, 178.5m, and 179.0m contour lines derived from the supplied topographic data. Figure 3.5 shows photographs of most of the shoreline covered by Figure 3.4. Those photographs were taken during our field review.

Minor modifications to the wave uprush limit were made during mapping of the flooding hazard limit to both smooth the hazard line and to more accurately reflect the corners of structures. The wave uprush limit line was first reviewed and hand edited to correct areas where corners of structures were “clipped” due to the alongshore resolution of the topographic data. An example of this can be seen with the wall structures on either side of 14th Street North. The corrected line was interpolated to 1m long segments, then smoothed with a routine that considered two neighbouring points to each vertex on the arc. The smoothed line was reviewed to ensure that the smoothing did not re-clip any of the corrected corners or otherwise produce an unrealistic looking limit. Figure 3.6 shows the portion of the flooding hazard limit presented in Figure 3.4 along with the pre-smoothed wave uprush limit line. It can be seen that the smoothing did not significantly alter the calculated wave uprush limit.

Effects of the cross-shore resolution of the topographic data, which are discussed in Section 3.2, were generally not corrected for. One exception to that was vertical walls upstream of the Nottawasaga River outlet, where the provincial default 15m horizontal wave uprush allowance was applied. The 15m default was applied for the properties between 36 Hiawatha Ave and 42 Shore Line East, inclusive. It was our judgement that the supplied topographic data did not provide suitable resolution to carry out a proper overtopping analysis for those wall structures.

An adjustment was also made to the wave uprush limit for the Wasaga Beach Provincial Park Area Two shoreline fronted by the boardwalk west of 3rd St. N. The adjustment was based on the results of a previous wave uprush study (Shoreplan, 2014). For the current study, using the NVCA topographic data, the wave uprush limit was calculated to be in the order of 6 to 8 metres beyond the 100-year flood line. However, during the Shoreplan (2014) study the wave uprush was found to extend approximately 6 to 9 metres further inland, depending on location, due to beach grading carried out by park staff. Sand excavated from in front of the boardwalk would increase overtopping and inland flooding during a design event, when compared to the NVCA data. This is the only location where the influence of beach grading was considered in our analyses.

It should be noted that the influence of dwellings was not considered in the wave uprush calculation. This led to the mapping of the flooding hazard limit landward of dwellings that are located within the flooding hazard, rather than showing the dwelling itself being an obstruction to the wave uprush.

3.2. Applying the Flooding Hazard Limit

NVCA currently assumes a 15m wave uprush allowance, which is the default allowance described by MNR (2001). We measured the mapped wave uprush allowance at 5m metre intervals for most of the dynamic beach shoreline, excluding creek and culvert outlets where curvature of the 178m contour (100-year instantaneous water level) made the measurements unrealistic. Figure 3.7 shows an example of the wave uprush measurements for the same location used in Figures 3.4 to 3.6. A total of 2,747 measurements were made with the wave uprush allowance varying between 2 and 45 metres. Only 115 measurements (4% of total) were greater than 20 metres, and those occurred where the backshore was either flat or sloped down from the beach crest, such as along portions of Eastdale Drive and Coastline Drive.

Figure 3.8 shows percentage occurrences and a cumulative percentage curve for the wave uprush measurements. It can be seen that most of the wave uprush measurements were in the order of 6 to 7 metres, and that more than 90% of the measurements were less than the MNR (2001) default allowance of 15m.

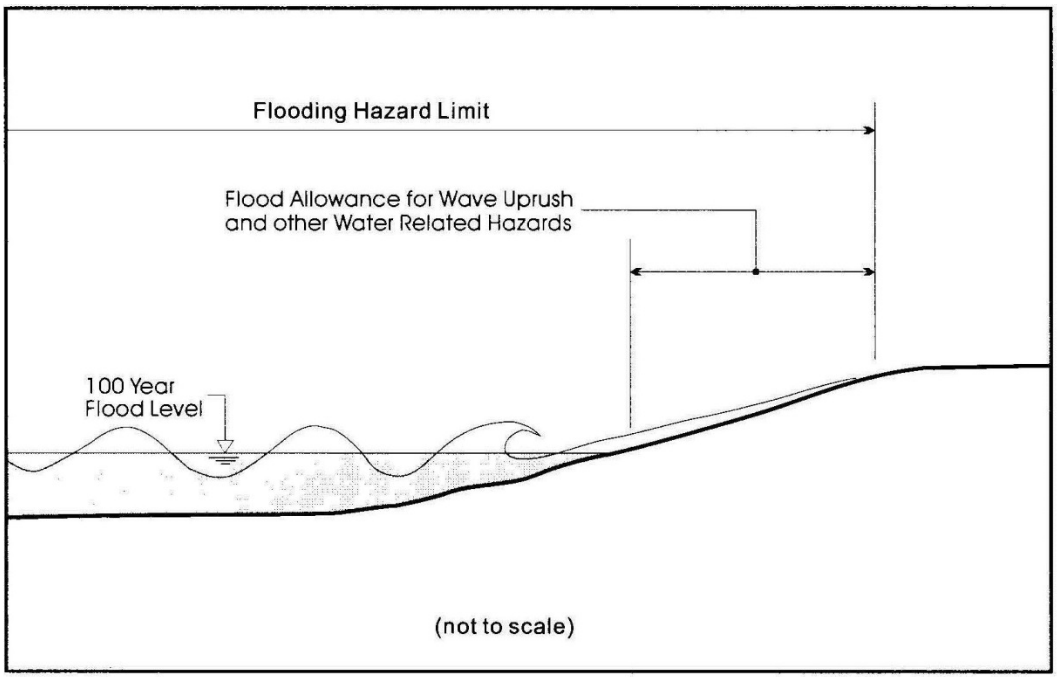
While the flooding hazard limit developed during this study represents a significant improvement to the previous flood hazard limit mapping used by NVCA, it still should be used as a planning tool, not as an absolute indication of where flooding can or cannot occur. The mapped flooding hazard limit represents the limit of wave uprush calculated for the criteria specified by provincial policy, using accepted scientific methods. It is possible for an event greater than that defined to occur (20-year return period storm occurring at the 100-year instantaneous water level).

The fact that sand beach profiles are dynamic and subject to change during storm events should not be ignored. Wave uprush elevations on a storm-altered profile could be either higher or lower than those calculated here. This study did not consider potential profile changes as that is not a step recommended in the MNR (2001) Technical Guides. Wave uprush calculations are not precise and suitable engineering judgment should be used in the application of our results, particularly if the consequences of flooding are considered to be severe.

There is also a limitation to the wave uprush calculations where a dune crest, shoreline bank, or structure is overtopped and the land behind the crest slopes downward. In those instances the methods employed may produce excessive uprush widths that would not be concluded during a site specific detailed analysis employing engineering judgement.

The impact of shore protection structures was considered in the wave uprush analysis because the topographic data included those structures, but the resolution of those structures was not as precise as occurs with a site specific survey. Because of the resolution of the topographic data, the shape of many of the structures gets smoothed to the extent that it can affect the wave uprush calculations. Individual development proposals may benefit from site specific wave uprush analyses. This study is well suited for an initial review of applications under Ontario Regulation 172/06, but we recommend that final approval not be denied solely on the basis of the hazard limits defined herein. Site specific studies, where completed, should be given priority consideration.

Figure 3.1 Flooding Hazard Limit Definition



from MNR, 2001

Figure 3.2 Design Wave for Uprush Analysis

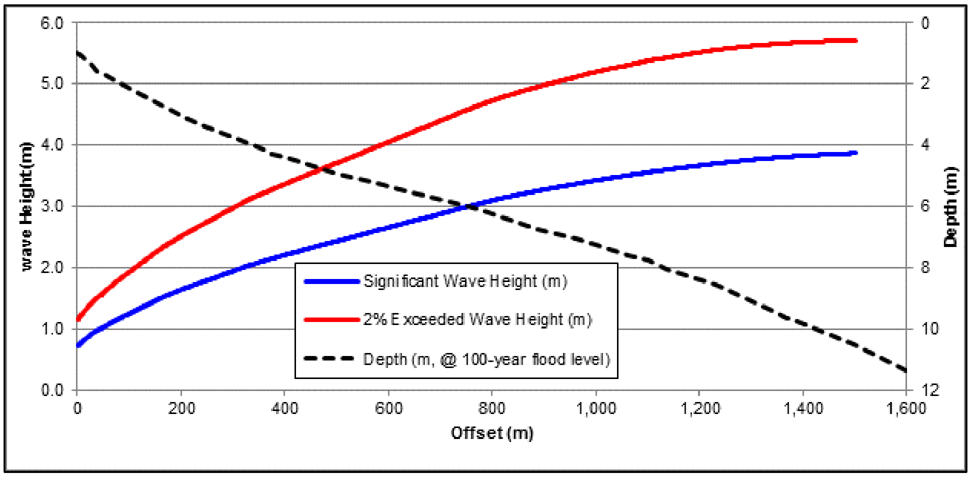
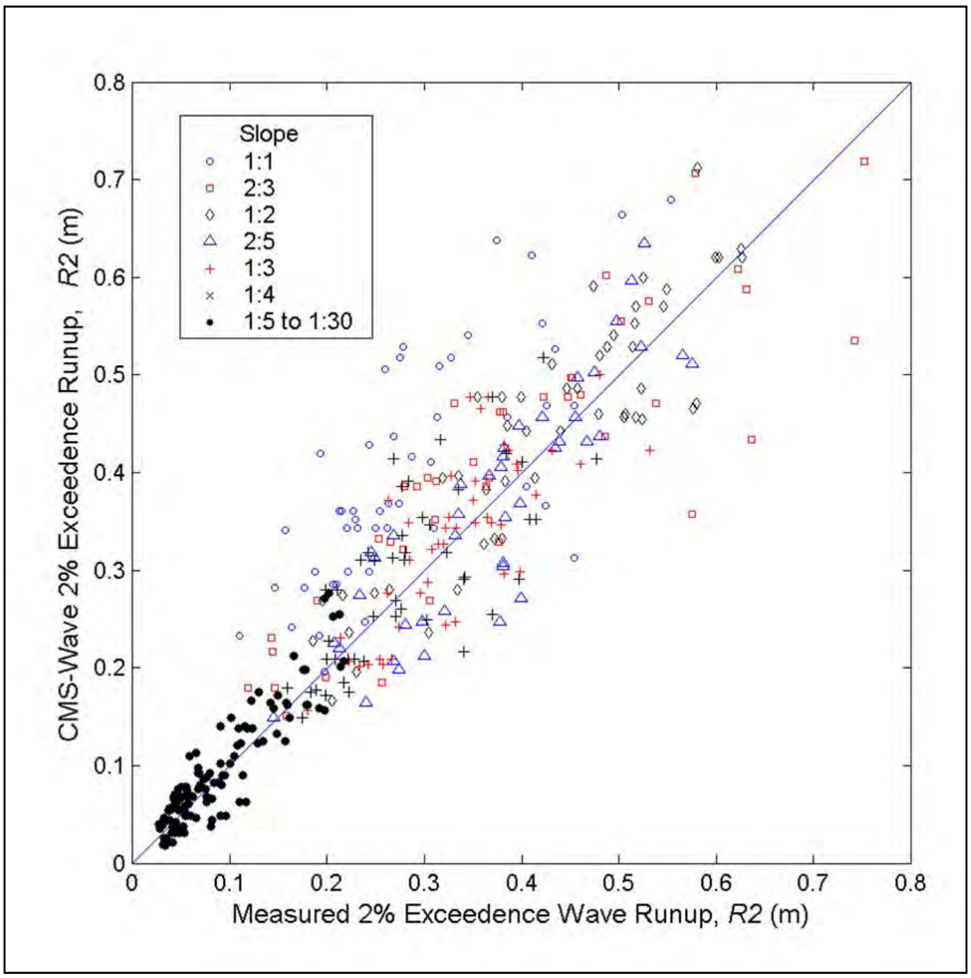


Figure 3.3 CMS-Wave Uprush Test Results



from Lin et al, (2008)

Figure 3.4 Example of Flooding Hazard Limit Mapping

Figure 3.5 Shoreline Near 14th Street North

Figure 3.6 Flooding Hazard Limit Smoothing for Mapping

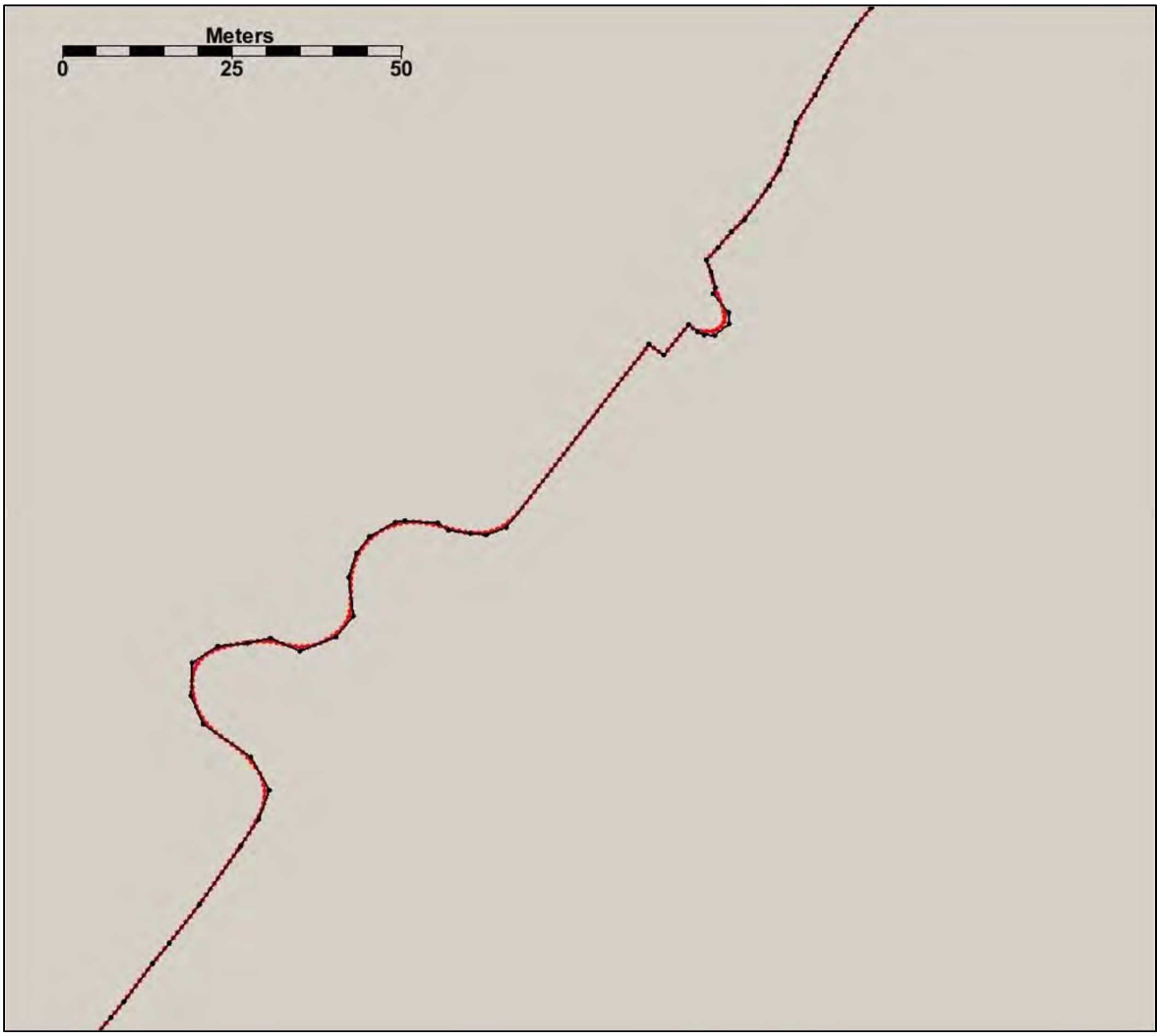
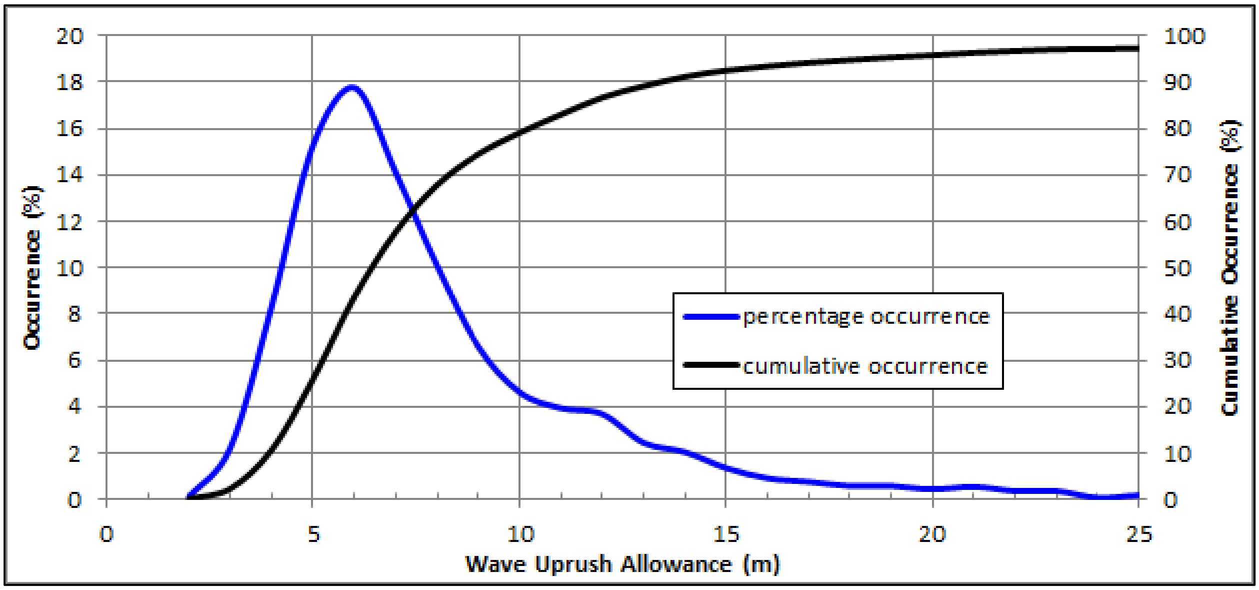


Figure 3.7 Example of Wave Uprush Allowance Measurements

Figure 3.8 Percentage Occurrences of Wave Uprush Allowance Distances



4. DYNAMIC BEACH HAZARD

The 2014 PPS defines the dynamic beach hazard as "areas of inherently unstable accumulations of shoreline sediments along the Great Lakes – St. Lawrence River System and large inland lakes, as defined by provincial standards, as amended from time to time. The dynamic beach hazard limit consists of the flooding hazard limit plus a dynamic beach allowance." MNR (2001) defines the dynamic beach allowance as either a 30 metre default allowance or an allowance based on a study using accepted scientific and engineering principles. The dynamic beach allowance was previously called the "Defined Portion of the Dynamic Beach". MNR (2001) notes that "Defined portions of the dynamic beach means those portions of the dynamic beach which are highly unstable and/or critical to the natural protection and maintenance of the first main dune feature and/or beach profile, where any development or site alteration would create or aggravate flooding or erosion hazards, cause updrift and/or downdrift impacts and/or cause adverse environmental impacts."

On sandy shorelines with dune systems, the dynamic beach is defined as including the embryo dune and foredune at the top of the beach. Those dunes receive wind-blown sand from the beach at lower water levels and supply sand to form breaker bars during storm events at high water levels. They are a critical component of the natural dynamic processes that occur on a beach. Figure 4.1 shows a typical cross-section of a well-developed dune system. In such a system the landward base of the foredune can be used to define the limit of the dynamic beach allowance, and hence the dynamic beach hazard limit. As the base of the foredune must be located with a site specific survey, which was not part of this project, we have not included this definition of the dynamic beach hazard limit in this study. The resolution of the supplied topographic data is not fine enough to accurately map the swales at the backs of the foredunes.

MNR (2001) notes that there are several circumstances under which natural factors may require a lakeward adjustment of the dynamic beach hazard limit, based on field investigations. These include where a cliff or bluff, consisting of cohesive sediments or bedrock, exists landward of the beach, and the toe of the bluff/cliff acts to limit the landward extent of dynamic beach profile adjustment. In these areas the dynamic beach hazard limit should be defined as the toe of the bluff or cliff.

It is our opinion that there can be analogous "practical limits" to the dynamic beach allowance associated with existing infrastructure and land uses, particularly where there is extensive development. Much of the developed shoreline east of 74th St. N fits that category. We consider most of the existing shoreline protection structures, buildings and roads that are located within 30 metres of the flooding hazard limit to constitute a practical limit to the dynamic beach allowance as they act to limit the landward extent of dynamic beach profile adjustment in the same manner as a bluff or cliff. The dynamic beach hazard limit mapping, discussed in Section 4.1 considers practical limits to the dynamic beach allowance.

The purpose of the practical limit of the dynamic beach allowance in a developed area is to recognize that the existing development has already altered the natural dynamic beach processes to the extent that there is no benefit to applying a 30m allowance at that location. This is discussed in more detail in Section 4.2

MNR (2001) defines three conditions which must be met before a section of beach shoreline is defined as a dynamic beach:

- beach or dune deposits exist landward of the waterline,
- beach or dune deposits overlying bedrock or cohesive material are equal to or greater than 0.3 metres in thickness, 10 metres in width and 100 metres in length along the shoreline,
- the maximum fetch is greater than 5 kilometres.

Using this definition, lateral boundaries were determined for two sections of dynamic beach shoreline. The eastern Town limit, which is the eastern limit of the study area, is one lateral boundary for this study because the dynamic beach shoreline extends into Tiny Township. For ease of reference, we have called this the eastern beach section. The western boundary of the eastern beach section was determined to be in the vicinity of 70th Street North, where the shoreline is cohesive rather than sand. The second section of dynamic beach, which we have called the western beach section, extends from approximately the end of Bay Street to 74th Street North.

Figure 4.2 shows the cohesive shore between the eastern and western beach sections described above. There is a pocket beach located within the section of cohesive shore, but it is not long enough to meet the definition of a dynamic beach.

The eastern limits of both beach sections are well defined; the eastern section because it is a study area limit and the western section because the beach is held in place by a narrow headland. The western limits of each beach segment are less well defined because the shore type transitions from sand beach to cohesive bank.

Figure 4.3 shows an eastern looking view of the of the western beach section, taken from its western boundary. This area consists of a thin sand deposit overlying a cohesive substrate. It is designated as a dynamic beach because it meets the three MNR conditions listed above, but the profile adjustments that will occur at this end of the beach will be constrained by the cohesive substrate. In terms of coastal processes, the cohesive shore is the controlling substrate. A site specific detailed analysis could show that this end of the beach should not be considered to be a dynamic beach. It should also be noted, however, that the dynamic beach allowance at the west end of the western beach section is defined by a cohesive bank and protection structures so the distinction of whether or not this is a dynamic beach shoreline may not have a significant impact on any development proposals.

Figure 4.4 is an aerial photograph of the western end of the eastern beach section. As with the western beach section, the west end of this beach transitions to a cohesive shore and the point at which the dynamic beach becomes a cohesive shore is not clearly defined. Again, however, the dynamic beach allowance here is limited by shoreline structures and a cohesive bank so an exact delineation of the lateral boundary of the dynamic beach may not be important.

Figure 4.4 also shows two vegetated areas where the dynamic profile changes associated with a dynamic beach will be limited due to the vegetation. It is likely that these areas exist because they have not been mechanically raked as elsewhere along the shoreline, but the greater presence of offshore cobbles suggests that the cohesive substrate may be at a higher elevation there. It is possible that a site specific detailed study could argue that these areas are cohesive shores, not dynamic beaches, but for this study we have classified them as dynamic beaches.

4.1. Mapping the Dynamic Beach Hazard Limit

The dynamic beach hazard limit was digitally mapped and provided to NVCA as a GIS shapefile. The hazard limit was defined as a 30m offset from the flooding hazard limit except where a practical limit to the dynamic beach allowance was applied due to natural or existing anthropogenic obstructions to the dynamic profile adjustments. Those obstructions included:

- cohesive banks,
- shoreline protection structures,
- solid fences that were landward of substantial dunes,
- buildings with solid foundations
- roads, parking lots, and culvert headwalls.

Some judgement was required while mapping the dynamic beach hazard limit, including:

- Practical limits to the dynamic beach allowance were “smoothed” to follow the general alignment of a series of adjacent dwellings or walls rather than stepping in and out with each structure.
- A single residential property that was “different” from adjacent properties was not sufficient to change the dynamic beach allowance. For example, if there was a single property with a shoreline protection wall amidst a series of unprotected properties, that wall was not considered to form a practical limit to the dynamic beach allowance. Such an argument can be made at assessed with a detailed site specific study.
- Three consistent residential properties were considered sufficient to either define a practical limit to the dynamic beach allowance, or to apply the 30m offset, as appropriate.
- Two consistent properties were evaluated on a case-by case basis, giving consideration to the adjacent shoreline conditions
- Individual structures that were adjacent to a practical limit to the dynamic beach allowance were included while defining the practical limit, but otherwise a single structure would not produce a practical limit. One example of this is a park washroom

building adjacent to a road would be considered along with the road while defining the limit.

Figure 4.5 shows an example of the dynamic beach hazard limit mapping. This is the same section of shoreline that was used to show the flooding hazard mapping in Figure 3.4. Figure 4.5 shows the flooding hazard limit, the 30m offset to the flooding hazard limit, and the dynamic beach hazard limit. The dynamic beach hazard limit either side of 14th Street is defined by the practical limit associated with the existing protection walls (top two photographs in Figure 3.5). On the west side of 14th Street the dynamic beach hazard line is actually lakeward of the flooding hazard line because the wall that limits dynamic beach profile adjustments is overtopped, and the flooding hazard limit is therefore landward of the wall.

The practical limit to the dynamic beach hazard limit carries straight across the end of the 14th Street road allowance since it is a road. Were it to have been a single residential property the same thing would have been done because it would not be practical to apply a 30m dynamic beach allowance to a single property like that. The dynamic beach hazard limit was stepped back to follow the 30m offset for the two properties further to the west (96 and 100 Shore Lane) for two reasons. This is an example of where judgement was used for two “different” properties, as described above. Firstly, 96 Shore Lane is double the width of the neighbouring properties, so this could be viewed as being similar to three consistent properties. More importantly, however, there is a substantial dune fronting these properties and it appears to be well stabilized with vegetation (see bottom photograph in Figure 3.5). There is merit to maintaining the natural beach processes at this site.

It is worth noting that had the beach fronting these properties been mechanically groomed like the adjacent beach, it would not have been unreasonable to extend the practical limit of the dynamic beach allowance in a straight line with the adjacent properties.

The 30m offset to the flooding hazard limit was also provided to NVCA as a GIS shapefile. Comparing the 30m offset to the dynamic beach hazard limit will show where practical limits to the dynamic beach allowance were assumed.

4.2. Applying the Dynamic Beach Hazard Limit

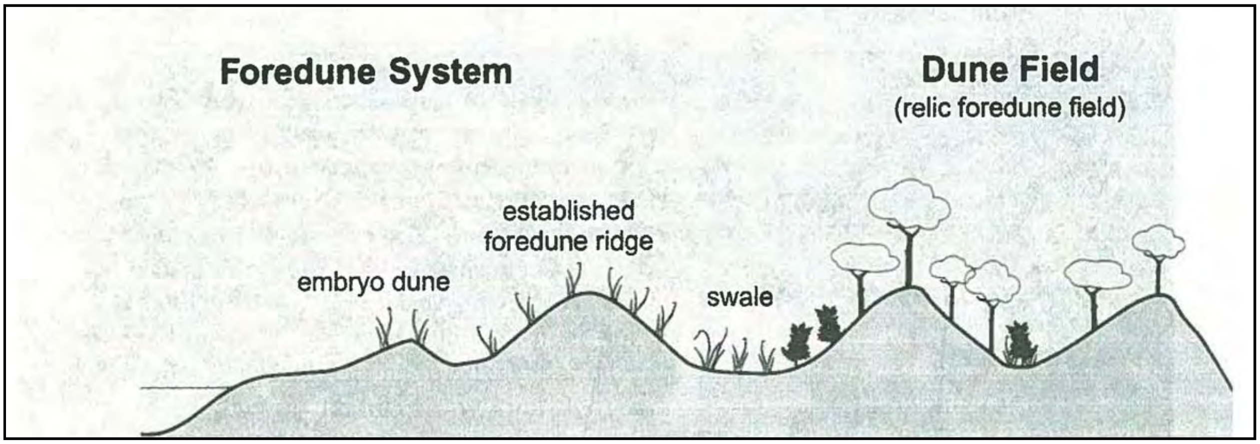
Judgement must be employed when considering the impact of the dynamic beach hazard limit on development proposals. If the practical limit of the dynamic beach hazard is defined by a wall structure, it does not follow that a dwelling should be permitted in close proximity to that wall just because that is the hazard limit. We generally support allowing infill development or re-development of properties with structures and dwellings in line with adjacent structures and dwellings for sections of shoreline with existing development. Where the practical limit of the dynamic beach hazard is defined by a row of existing development it is unlikely that allowing infill development in that same alignment will have a detrimental impact on the natural beach processes. Where the practical limit of the dynamic beach hazard is defined by existing wall structures it is still usually recommended that infill development be kept in line with existing dwellings.

Where the dynamic beach hazard limit is based on the 30m setback from the flooding hazard limit, limitations associated with the location of the flooding hazard limit (see Section 3.2) will also apply to the dynamic beach hazard limit. For development that is proposed at a location between the 30m offset from the flooding hazard limit and the dynamic beach hazard limit that is based on a practical dynamic beach allowance, it may be necessary to complete a site specific detailed review of the hazards at that site. The reason that a practical limit to the dynamic beach allowance was assumed need to be considered during assessment of the development proposal. As was stated with the flooding hazard limit, we recommend that final development approval not be denied solely on the basis of the dynamic beach hazard limits defined in this study.

It is our expectation that development proposed for locations that are landward of the dynamic beach hazard limit based on a 30m offset will not require additional analysis beyond what was completed for this study. It is possible that there may be site specific exceptions to that expectation, but in most cases the 30m setback will be sufficient to allow natural dynamic beach processes.

For properties with well-established foredunes a site specific survey that locates the base of the foredune can be used to establish the dynamic beach hazard limit. It must be noted, however, that many of the dunes within the study area are not well enough formed that a mature foredune can be accurately located.

Figure 4.1 Dune Schematic



(from Introduction to Coastal Processes and Geomorphology, Davidson-Arnott, 2010.

Figure 4.2 Dynamic Beach Lateral Limits

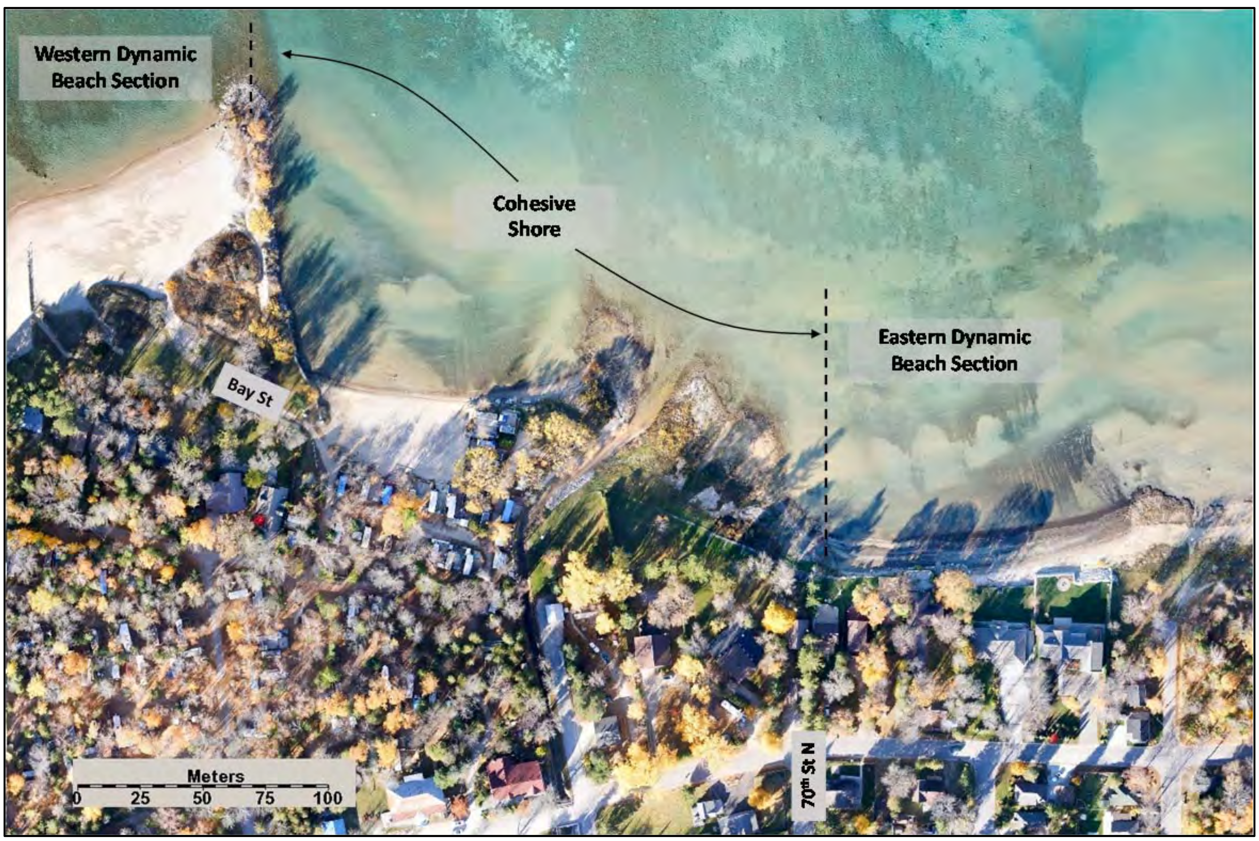


Figure 4.3 Western End of Western Beach Section

Figure 4.4 Western End of Eastern Beach Section

Figure 4.5 Example of Dynamic Beach Hazard Limit Mapping

5. SUMMARY AND CONCLUSIONS

This study presents updated flooding hazard limit and dynamic beach hazard limits for the Georgian Bay shoreline within the limits of the Town of Wasaga Beach. The flooding hazard limit was determined from wave uprush analyses for a 20-year storm event occurring at the 100-year instantaneous water level. Bathymetric and topographic data for the wave uprush analysis was generated by other participants in the LSSEGBCUF program. More than 90% of the calculated wave uprush allowance along the dynamic beach shoreline was found to be less than the 15m default allowance currently considered by NVCA.

The dynamic beach hazard limit was defined as either a 30m default setback from the flood hazard limit, or as a practical limit caused by a natural or anthropogenic obstruction that limited the dynamic beach profile adjustments. The anthropogenic obstructions included shoreline protection structures, buildings with solid foundations, roads, parking lots, and solid fences located landward of substantial dunes. These obstructions were identified through both aerial photographs supplied by NVCA and from a field review conducted by Shoreplan staff.

Three GIS shapefiles accompany this report: the flood hazard limit, the 30m setback from the flood hazard limit, and the dynamic beach hazard limit. Comparing the latter two of these shapefiles will show where practical limits to the dynamic beach allowance were assumed.

The hazard limits developed during this study represent a significant improvement to the previous hazard limit mapping used by NVCA, yet it still should be used as a planning tool, not as an absolute limit of where those hazards can or cannot occur. The resolution of the wave uprush analysis, and hence the flooding and dynamic beach hazard limits, produced by this study will not match what can be obtained through a site-specific detailed analysis. This study is well suited for an initial review of applications under Ontario Regulation 172/06, but we recommend that final approval not be denied solely on the basis of the hazard limits defined herein. Site specific studies, where completed, should be given priority consideration.

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APPENDIX A FIELD REVIEW PHOTOGRAPH LOCATIONS

Digital copies of selected photographs from our field review are provided under separate cover. Table A1 presents a list of the UTM Zone 17 (NAD83) coordinates of those photographs. The photographs were geo-tagged by the camera's built-in GPS system which occasionally recorded an incorrect location if a proper signal was not obtained. Where this was identified the coordinates presented in Table 1 were corrected so those values take precedence over the geo-tagged values in the digital copies of the photographs.

Table A1 Field Review Photograph Coordinates (UTM Zone 17, NAD83)

Photo	Easting	Northing	Photo	Easting	Northing	Photo	Easting	Northing
1	579,701	4,935,058	34	579,782	4,934,242	67	579,337	4,933,168
2	579,708	4,935,045	35	579,779	4,934,234	68	579,334	4,933,161
3	579,747	4,935,047	36	579,751	4,934,164	69	579,334	4,933,136
4	579,750	4,935,043	37	579,677	4,933,988	70	579,332	4,933,132
5	579,786	4,934,981	38	579,673	4,933,990	71	579,354	4,933,090
6	579,782	4,934,983	39	579,693	4,933,982	72	579,310	4,933,046
7	579,803	4,934,934	40	579,617	4,933,848	73	579,288	4,932,976
8	579,810	4,934,928	41	579,620	4,933,865	74	579,275	4,932,927
9	579,819	4,934,885	42	579,601	4,933,879	75	579,261	4,932,910
10	579,819	4,934,885	43	579,599	4,933,878	77	579,242	4,932,882
11	579,818	4,934,873	44	579,551	4,933,750	78	579,253	4,932,864
12	579,820	4,934,875	45	579,464	4,933,580	80	579,230	4,932,843
13	579,824	4,934,858	46	579,468	4,933,586	81	579,198	4,932,795
14	579,824	4,934,818	48	579,437	4,933,600	82	579,196	4,932,757
15	579,819	4,934,828	49	579,438	4,933,460	83	579,183	4,932,753
16	579,823	4,934,746	50	579,446	4,933,436	84	579,152	4,932,700
17	579,824	4,934,740	51	579,446	4,933,435	86	579,129	4,932,685
18	579,815	4,934,676	52	579,437	4,933,428	87	579,134	4,932,668
19	579,803	4,934,651	53	579,419	4,933,420	88	579,090	4,932,604
20	579,803	4,934,651	54	579,402	4,933,421	89	579,089	4,932,595
21	579,830	4,934,577	55	579,402	4,933,426	90	579,035	4,932,549
22	579,805	4,934,530	56	579,397	4,933,420	91	579,032	4,932,527
23	579,796	4,934,521	57	579,393	4,933,402	92	579,043	4,932,505
24	579,797	4,934,499	58	579,389	4,933,368	93	579,040	4,932,501
25	579,836	4,934,462	59	579,388	4,933,351	94	579,024	4,932,498
26	579,822	4,934,459	60	579,372	4,933,301	95	578,987	4,932,404
27	579,810	4,934,472	61	579,366	4,933,284	96	578,984	4,932,399
28	579,842	4,934,466	62	579,356	4,933,244	97	578,995	4,932,386
29	579,834	4,934,458	63	579,348	4,933,197	98	578,947	4,932,322
30	579,791	4,934,379	64	579,335	4,933,184	99	578,952	4,932,322
31	579,803	4,934,308	65	579,344	4,933,180	101	578,920	4,932,251
32	579,803	4,934,336	66	579,344	4,933,181	102	578,903	4,932,256

Table A1 (cont.) Field Review Photograph Coordinates (UTM Zone 17, NAD83)

Photo	Easting	Northing	Photo	Easting	Northing	Photo	Easting	Northing
103	578,904	4,932,215	152	576,843	4,929,206	201	575,423	4,927,514
104	578,885	4,932,168	153	576,843	4,929,207	202	575,391	4,927,476
106	578,869	4,932,131	154	576,844	4,929,206	203	575,397	4,927,476
107	578,870	4,932,133	155	576,771	4,929,118	204	575,370	4,927,458
108	578,825	4,931,993	156	576,780	4,929,135	205	575,254	4,927,313
109	578,828	4,931,996	157	576,695	4,929,014	206	575,066	4,927,154
110	578,836	4,931,977	159	576,593	4,928,902	207	575,048	4,927,105
111	578,838	4,931,980	164	576,598	4,928,906	208	575,014	4,927,063
112	578,836	4,931,978	165	576,536	4,928,842	209	575,019	4,927,041
113	578,827	4,932,020	166	576,542	4,928,836	210	575,016	4,927,039
114	578,863	4,932,102	167	576,492	4,928,760	211	574,992	4,927,033
115	578,461	4,931,543	168	576,492	4,928,762	212	574,976	4,927,010
118	578,453	4,931,542	169	576,420	4,928,673	213	574,900	4,926,957
119	578,491	4,931,473	170	576,356	4,928,597	214	574,894	4,926,956
120	578,022	4,930,743	171	576,351	4,928,569	215	574,912	4,926,966
121	578,037	4,930,798	172	576,344	4,928,585	217	574,894	4,926,929
122	578,006	4,930,795	173	576,334	4,928,585	218	574,796	4,926,838
123	578,005	4,930,744	174	576,337	4,928,583	219	574,790	4,926,818
124	578,006	4,930,741	175	576,341	4,928,574	220	574,741	4,926,769
125	578,275	4,930,993	176	576,277	4,928,491	221	574,651	4,926,681
126	578,292	4,931,089	177	576,275	4,928,488	224	574,559	4,926,626
127	578,350	4,931,296	178	576,231	4,928,436	225	574,520	4,926,547
128	578,358	4,931,387	179	576,176	4,928,364	226	574,518	4,926,544
129	578,476	4,931,634	180	576,168	4,928,383	228	574,333	4,926,437
130	578,468	4,931,634	181	576,171	4,928,379	229	574,372	4,926,425
131	578,463	4,931,622	182	576,101	4,928,286	230	574,342	4,926,422
132	578,591	4,931,766	183	576,101	4,928,289	231	574,302	4,926,380
133	578,594	4,931,768	184	576,101	4,928,289	232	574,262	4,926,343
134	578,596	4,931,767	185	576,101	4,928,289	234	574,212	4,926,306
135	578,595	4,931,773	186	575,985	4,928,132	235	574,218	4,926,295
136	577,377	4,929,781	187	575,999	4,928,115	238	574,139	4,926,231
137	577,367	4,929,780	188	575,915	4,928,042	239	574,046	4,926,147
138	577,370	4,929,838	189	575,916	4,928,037	240	574,042	4,926,140
139	577,312	4,929,850	190	575,885	4,927,957	242	574,046	4,926,113
140	577,312	4,929,850	191	575,884	4,927,945	243	574,010	4,926,097
141	577,312	4,929,849	192	575,806	4,927,902	244	574,017	4,926,094
142	577,145	4,929,614	193	575,707	4,927,795	245	573,890	4,925,995
143	577,143	4,929,615	194	575,681	4,927,757	246	573,884	4,926,005
144	577,102	4,929,541	195	575,637	4,927,736	247	573,877	4,926,009
145	577,105	4,929,540	196	575,623	4,927,714	248	573,772	4,925,924
146	577,048	4,929,481	197	575,496	4,927,582	249	573,729	4,925,877
148	576,998	4,929,441	199	575,491	4,927,599	250	573,717	4,925,866
149	576,927	4,929,337	200	575,440	4,927,531	251	573,662	4,925,803

Table A1 (cont.) Field Review Photograph Coordinates (UTM Zone 17, NAD83)

Photo	Easting	Northing		Photo	Easting	Northing		Photo	Easting	Northing
252	573,668	4,925,818		295	571,974	4,924,759		341	570,574	4,924,517
253	573,609	4,925,798		296	571,843	4,924,707		343	570,478	4,924,479
254	573,576	4,925,725		297	571,861	4,924,686		344	570,448	4,924,474
255	573,585	4,925,730		298	571,783	4,924,675		345	570,404	4,924,465
256	573,505	4,925,707		299	571,781	4,924,668		346	570,374	4,924,463
257	573,512	4,925,704		300	571,742	4,924,624		347	570,332	4,924,465
258	573,460	4,925,666		301	571,761	4,924,657		348	570,332	4,924,447
259	573,435	4,925,657		302	571,760	4,924,662		349	570,317	4,924,450
260	573,362	4,925,593		303	571,644	4,924,600		350	570,299	4,924,443
261	573,306	4,925,572		305	571,644	4,924,600		351	570,266	4,924,460
262	573,316	4,925,568		306	571,575	4,924,577		353	570,221	4,924,448
263	573,324	4,925,571		307	571,579	4,924,577		354	570,228	4,924,463
264	573,215	4,925,501		308	571,578	4,924,576		355	569,794	4,924,666
265	573,219	4,925,493		309	571,836	4,924,687		356	569,790	4,924,671
266	573,160	4,925,443		310	571,505	4,924,555		358	569,792	4,924,670
267	573,090	4,925,402		311	571,461	4,924,521		360	569,791	4,924,670
268	573,067	4,925,375		312	571,393	4,924,523		361	569,577	4,924,854
269	572,960	4,925,339		314	571,358	4,924,517		362	569,576	4,924,852
270	572,987	4,925,305		315	571,332	4,924,518		363	569,576	4,924,852
271	572,892	4,925,242		316	571,343	4,924,514		364	569,578	4,924,856
272	572,902	4,925,226		317	571,343	4,924,516		365	569,570	4,924,840
273	572,806	4,925,162		318	571,242	4,924,513		366	569,393	4,924,961
274	572,500	4,925,003		319	571,240	4,924,505		367	569,394	4,924,960
275	572,740	4,925,152		320	571,243	4,924,506		368	569,394	4,924,959
276	572,728	4,925,162		321	571,099	4,924,514		369	569,396	4,924,959
277	572,644	4,925,120		322	571,106	4,924,507		370	569,283	4,925,036
278	572,644	4,925,120		323	571,085	4,924,510		371	569,285	4,925,035
279	572,541	4,925,042		324	571,093	4,924,506		372	569,112	4,924,935
280	572,479	4,925,010		325	571,044	4,924,570		373	569,040	4,924,925
281	572,451	4,924,998		326	571,018	4,924,534		374	568,992	4,924,990
282	572,409	4,924,976		327	571,019	4,924,542		375	568,991	4,925,000
283	572,364	4,924,938		328	571,004	4,924,568		376	568,841	4,925,052
284	572,355	4,924,926		329	571,012	4,924,577		377	568,844	4,925,047
285	572,331	4,924,922		330	570,917	4,924,562		378	568,842	4,925,045
286	572,307	4,924,913		331	570,919	4,924,566		379	568,764	4,925,104
287	572,288	4,924,905		332	570,886	4,924,670		380	568,766	4,925,110
288	572,285	4,924,903		333	570,886	4,924,666		381	568,766	4,925,113
289	572,281	4,924,900		334	570,808	4,924,639		382	568,768	4,925,144
290	572,226	4,924,866		335	570,786	4,924,636		383	568,676	4,925,185
291	572,222	4,924,874		336	570,733	4,924,588		384	568,675	4,925,183
292	572,169	4,924,850		337	570,667	4,924,556		385	568,676	4,925,182
293	572,119	4,924,828		339	570,627	4,924,535		386	568,665	4,925,187
294	572,040	4,924,778		340	570,576	4,924,518		387	568,664	4,925,190

Table A1 (cont.) Field Review Photograph Coordinates (UTM Zone 17, NAD83)

Photo	Easting	Northing
389	568,662	4,925,192
390	568,664	4,925,192
391	568,556	4,925,223
392	568,548	4,925,227
393	568,484	4,925,284
395	568,486	4,925,287
396	568,439	4,925,360
397	568,423	4,925,357
398	568,425	4,925,358
399	568,352	4,925,474
400	568,334	4,925,466
401	568,332	4,925,464
402	568,330	4,925,462
403	568,330	4,925,464
404	568,330	4,925,464
405	568,330	4,925,458
406	568,181	4,925,532
407	568,176	4,925,559