Port Darlington Shore Protection Concepts

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1. Introduction

1.1 Scope of Work

This report provides an overview of coastal processes and alternatives for addressing shoreline erosion, for the shoreline from the mouth of Bowmanville Creek to St. Marys Cement, located on Lake Ontario, in the Municipality of Clarington. The study area is approximately 1.8 km in length, and includes the shorelines along West Beach Road, Cove Road and Cedar Crest Beach Road. The objective of the study was to develop concept level shore protection alternatives, with a focus on beach enhancement. It is recognized that these shore protection concepts will address erosion but will not address flooding concerns outlined in the report. The report includes an overview of coastal processes, development of four shore protection concepts, an opinion of probable cost, an evaluation of the shore protection concepts and recommendations for next steps. Climate change impacts are discussed in general terms.

A site visit was undertaken on December 6, 2017 with personnel from Baird, CLOCA, Aqua Solutions 5 and property owners. In addition, Baird personnel attended a Public Meeting on March 3, 2018 and heard property owners speak about their experiences on the shoreline and their concerns.

1.2 Background and Site Location

The study shoreline is located on the west side of Bowmanville Creek and adjacent to Westside Creek, and extends from the harbour to St. Marys Cement, as shown in Figure 1.1. A detailed description of the shoreline is provided in Section 2.1.

The shoreline is subject to flooding and erosion and was identified by Central Lake Ontario Conservation Authority (CLOCA), as a Damage Centre in 1990 (Sandwell Swan Wooster, 1990). In 2004, CLOCA retained Aqua Solutions to assess and make recommendations for planning and policy procedures to address the hazards and future development applications in the study area.

CLOCA's Policy and Procedural Document for Regulation and Plan Review (2013) provides policy direction on how CLOCA administers and implements Ontario Regulation 42/06: Central Lake Ontario Conservation Authority Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses.

In 2016, residents along Cedar Crest Beach Road presented a petition to the Municipality of Clarington Council, asking for municipal assistance with coordinating a unified plan for erosion mitigation on private lands in the Cedar Crest Beach area. This study was undertaken in response to the residents' request for a coastal engineering study to assess shore protection options.

The present study is part of a larger Port Darlington Damage Centre Study with the objective of providing a science-based platform upon which subsequent decisions related to shoreline management may be made.

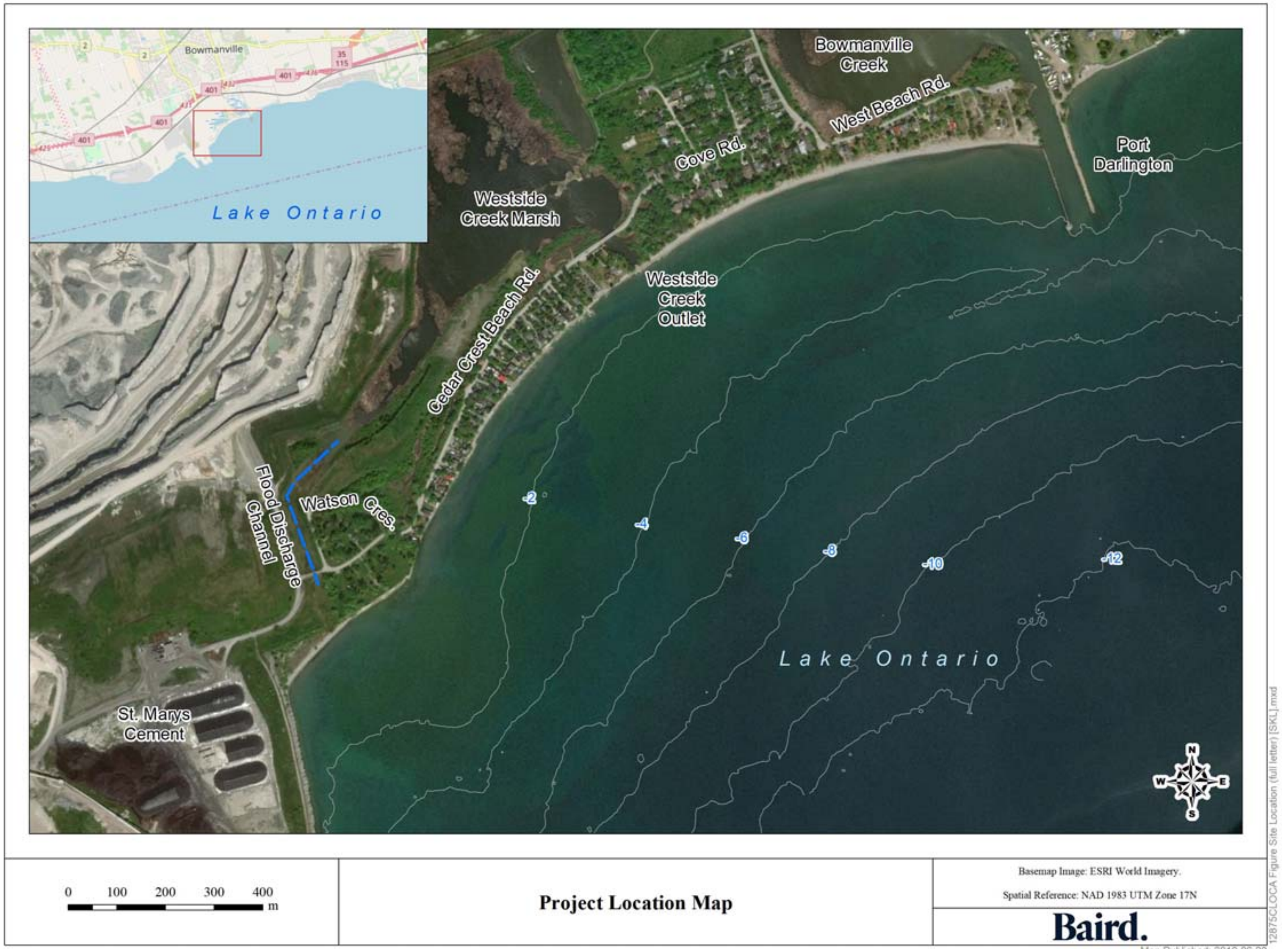

Figure 1.1: Site location map showing key features

2. Coastal Conditions

2.1 Shoreline Description

The study shoreline extends for 1.8 km from the eastern limit of St. Marys Cement to the mouth of Bowmanville Creek as shown in Figure 1.1. There are two creeks that flow into Lake Ontario along the study shoreline: Westside Creek; and Bowmanville Creek. Both are backed by low lying marsh.

The west end of the study shoreline features eroding cohesive bluffs. A fillet beach has deposited at the west end of the reach, adjacent to the St. Marys Cement pier as shown in Figures 2.1 and 2.2. The beach is sand, cobble and boulder composition. A drainage channel has been excavated from the Westside Creek Marsh. On the day of the site visit (December 6, 2017), the beach deposit obstructed the channel mouth.

East of the cohesive bluff, along the shoreline backed by Cedar Crest Beach Road, the shoreline historically was a barrier beach, separating the Westside Creek Marsh from Lake Ontario. Presently, it is developed with permanent residences. The area has experienced erosion and flooding, and the shoreline is armoured with various types of protection including concrete wall, armourstone, gabions and ad hoc protection; examples are shown in Figures 2.3 to 2.6.

Westside Creek marks the eastern limit of Cedar Crest Beach Road. A sand and cobble bar obstructed flow at the creek mouth on the day of the site visit (Figure 2.7). The mouth had been dredged to permit flow and dredge spoil was visible on the east bank.

The shoreline east of Westside Creek, backed by Cove Road is a sand and cobble beach. The properties are deeper than those along Cedar Crest Beach Road, and houses are generally setback further from Lake Ontario as shown in Figures 2.8 and 2.9. Shore protection structures have generally not been constructed and the beach has a natural appearance.

West Beach Road is located east of Cove Road. This stretch of shoreline is a sandy barrier beach that separates the Bowmanville Marsh from Lake Ontario. The beach has accreted as sediment is transported in an easterly direction and deposits on the west side of the breakwater at the mouth of Bowmanville Creek (Figure 2.10). The breakwaters that mark the entrance to Bowmanville Harbour are in a state of disrepair, and the sand is now bypassing the west breakwater by moving over, through and around the offshore end of the structure, and depositing in the channel. This is discussed further in Section 2.4. The houses are generally set back from Lake Ontario and the beach is unprotected along this shoreline.

Figure 2.1: West end of study shoreline with fillet beach deposit on east side of St. Marys Cement

Figure 2.2: Eroding bluff and cobble and boulder beach at west end of study shoreline

Figure 2.3: Concrete block revetment at Cedar Crest Beach Road

Figure 2.4: Armourstone protection at Cedar Crest Beach Road

Figure 2.5: Concrete seawall at Cedar Crest Beach Road

Figure 2.6: Gabion shore protection at Cedar Crest Beach Road

Figure 2.7: Mouth of Westside Creek with dredge spoil visible on east bank

Figure 2.8: View east from Westside Creek along beach backed by Cove Road

Figure 2.9: Shoreline backed by Cove Road in centre of image, showing larger setbacks for houses compared to adjacent shorelines along Cedar Crest Beach Road and West Beach Road

Figure 2.10: View east along shoreline fronting West Beach Road with Darlington Harbour pier in background

2.2 Bathymetry

The 2001 Scanning Hydrographic Operational Airborne LiDAR Survey (SHOALS) data were used to define the bathymetry in the study area. Figure 2.11 shows a shallower shelf feature at the west end of the study site, indicating harder substrate compared to the lakebed to the east. The contours indicate an area of sediment deposition on the west side of the breakwater west of Bowmanville Creek where the fillet beach has deposited.

Figure 2.11: Bathymetry data from 2001 SHOALS

2.3 Water Levels

Water levels on Lake Ontario vary in the long-term and seasonally in response to climatic conditions, and in the short term due to the passage of individual storm events. The typical seasonal variation on Lake Ontario is approximately 0.5 m, with the average low occurring in December and the average high occurring in June. The highest recorded monthly mean level on Lake Ontario is 75.81 m IGLD 1985, recorded in June 2017 (see Figure 2.12).

The Lake Ontario Flood Hazard Limit is defined as the 100-year flood level (including surge) plus an allowance for wave uprush and other water related hazards (MNR, 2001). The MNR 100-year flood level for Oshawa (the nearest station to Port Darlington), is 75.68 m IGLD 1985 (75.62 m GSC) as defined in MNR (1989). Monthly mean water levels in June 2017 exceeded this elevation.

When high lake levels combine with storm waves, wave uprush and overtopping occur; these factors are considered in defining the flood hazard limit and when designing shore protection. CLOCA's Flood and Erosion Risk Map (Environment Canada, MNR, CLOCA, 1990) shows a 100-year flood level including wave uprush of 76.27 m IGLD 1955 (76.40 m IGLD 1985 or 76.34 m GSC) for the study shoreline.

Most of the study shoreline, with the exception of the bluff at the west end is also susceptible to flooding from Bowmanville Creek and Westside Creek. The most recent floodplain mapping shows the following flood elevations:

- Cedar Crest Beach Road: 76.7 m GSC (Westside Creek Floodplain Mapping; CLOCA 2013)
- West Beach Road: 78.1 m GSC (Bowmanville and Soper Creek Floodplain Mapping; Aquafor Beech Ltd., 2009)

Elevations along Cedar Crest Beach Road are generally below 76.0 m GSC and elevations along West Beach Road are typically in the range of 75.7 m GSC.

This means the shoreline along Cedar Crest Beach Road and West Beach Road is generally more than 0.3 m below the 100-year flood level for Lake Ontario (when wave uprush is considered). Similarly, Cedar Crest Beach Road is 0.7 m below the flood level for Westside Creek and West Beach Road is more than 2 m below the flood level for Bowmanville and Soper Creek. Therefore, while shoreline protection measures can mitigate erosion at this site, they will not address the flood hazard from inland, and flooding from Lake Ontario will continue to be a concern at high water levels.

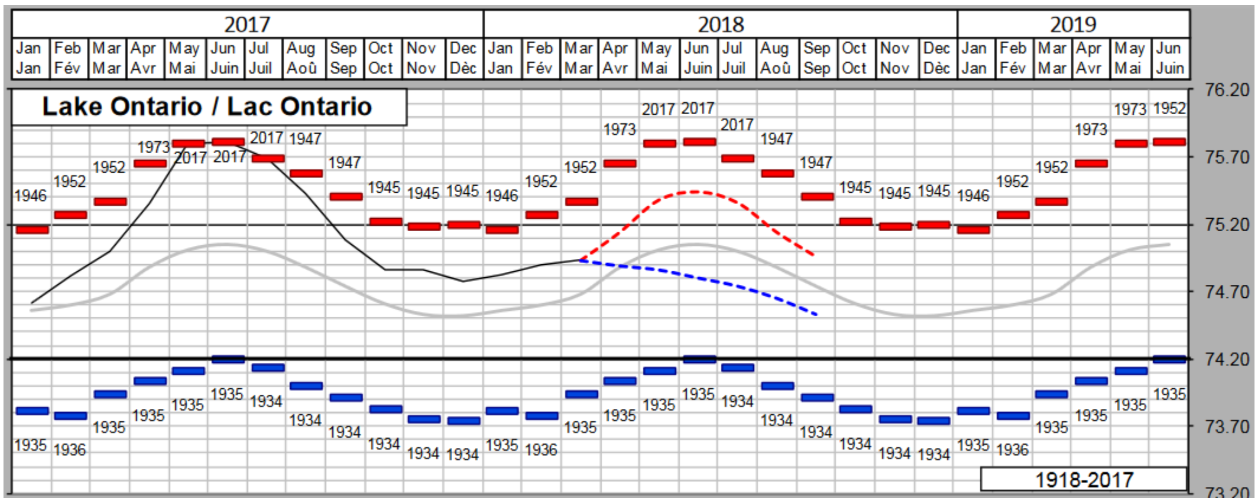

Figure 2.12: Lake Ontario monthly mean water levels (m IGLD 1985)

2.4 Sediment Processes

The study shoreline is in an embayment formed between Port Darlington and St. Marys Cement pier. The west end of the study area, and the shoreline to the east of Bowmanville Creek, are cohesive shorelines, with relatively high eroding till bluffs. The shoreline between the cohesive bluffs is the low lying flood plains of Westside Creek and Bowmanville Creek.

The central portion of the flood plain, along Cedar Crest Beach Road (highlighted with a blue arrow in Figure 2.13), has an approximate SW-NE orientation and is prone to flooding and erosion. As noted earlier, cohesive bluffs approximately 3 to 4 m high with significant sand and gravel content back the shoreline at the southwest end of the study area. Lakebed contours indicate the presence of a shallow shelf in front of the bluffs representing bedrock or cobble/boulder lag left on the lakebed. The -2 m lakebed depth contour is closest to the shoreline in the area around the Westside Creek mouth exposing this area of shoreline to higher wave energy.

Water discharges from Westside Creek Marsh into Lake Ontario through Westside Creek and a flood canal that was constructed immediately east of the St. Marys Cement pier. During the site visit, both the flood canal and the creek mouth were obstructed by a sand and gravel bar formed as a result of littoral transport. The sand and gravel bar would prevent or delay the discharge of flood waters from the marsh and discharge canal.

There are two armourstone breakwaters at the mouth of Bowmanville Creek and entrance to Port Darlington Harbour. Sediment has accumulated on the west side of the breakwaters and the harbour entrance requires regular maintenance dredging.

Figure 2.14 shows the 1955 shoreline on a 2014 satellite image thus defining long-term shoreline erosion and accretion areas in a qualitative manner. Recession of the top of bluff line at the west end of the study shoreline between 1955 and 2014 was approximately 0.2 to 0.3 m/year on average. Shoreline recession was highest along Cedar Crest Beach Road and decreases in an easterly direction. From West Beach Road eastward the shoreline has accreted over the period of comparison. Quantitative estimates of shoreline recession rates requires a more detailed investigation including examination of additional aerial imagery, consideration of lake levels at the time of each image, and chronology of construction of shore protection structures, and is beyond the scope of this study.

Baird's previous experience with the wave field on Lake Ontario indicates that waves arrive at the study shoreline from two different directions, namely; southwest and east. Southwesterly waves are more frequent. The direction of Longshore Sediment Transport (LST) along a shoreline depends on the relative angle between the local shoreline orientation and incoming wave direction. Since waves arrive from two different directions, sediment along the study shoreline is expected to move back and forth depending on the wave conditions. Figure 2.14 shows the net transport direction; net transport is in a westerly direction from the bluffs at the west end of the study shoreline resulting in closure of the mouth of the flood channel and creation of the small fillet beach deposit on the east side of the St. Marys Cement pier. Along the remainder of the study shoreline, net transport is to the east. It is possible that some sediment is bypassing the breakwaters at the entrance to Port Darlington Harbour. The rate of bypassing cannot be quantified without further studies using more recent bathymetry information. Bathymetry contours around the breakwaters (Figure 2.11) do not feature a bypassing shoal, therefore, the rate of bypassing is not expected to be significant. As the breakwaters are in a state of disrepair, it is also likely that sediment is being transported over (e.g. by wind) and through the armourstone structures.

The piers at St. Marys are approximately 650 m long (measured from the nearby shoreline) and extend to -8 m CD. It is expected that they act as a complete barrier to alongshore movement of granular sediment (i.e., sand and gravel) and, therefore, there is no exchange of granular sediment between west and east shorelines on either side of the piers. As a result, at present local bluff erosion and any potential sediment load from the creeks are the only sources of beach size material to the shoreline between Port Darlington and St. Marys Cement. Net alongshore transport in the study area is generally towards the east. This means that St. Marys piers would block any potential supply of sediment available (e.g., through bluff erosion) from the westerly shorelines. In fact, shoreline comparisons for the shoreline immediately west of the St. Marys piers conducted previously by Baird indicated a growing fillet beach since construction of the piers. Comparison of the 2000 and 2007 shorelines indicated approximately 2,000 m^3 of sand had been deposited annually in the local fillet beach immediately west of the piers. In summary, there are three potential impacts by the St. Marys piers on the study shoreline: 1) interruption of sediment supply from the shorelines west side of the piers (approximately 2,000 m^3/year as evident from formation of the fillet beach on the west side of the piers); and 2) reversal of longshore transport along the shoreline immediately east of the piers (as evident from formation of the fillet beach on the east side of the piers); and 3) loss of sediment supply from the shoreline protected by the St. Marys piers.

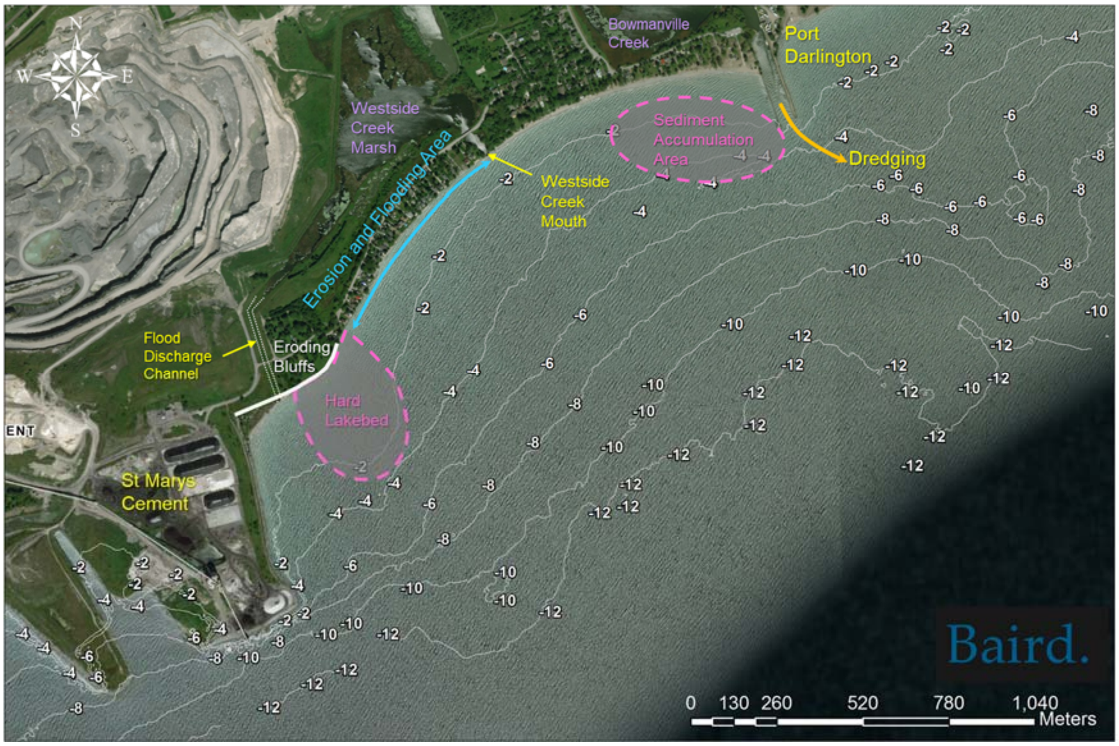

Figure 2.13: Overview of the study area showing key sediment processes features

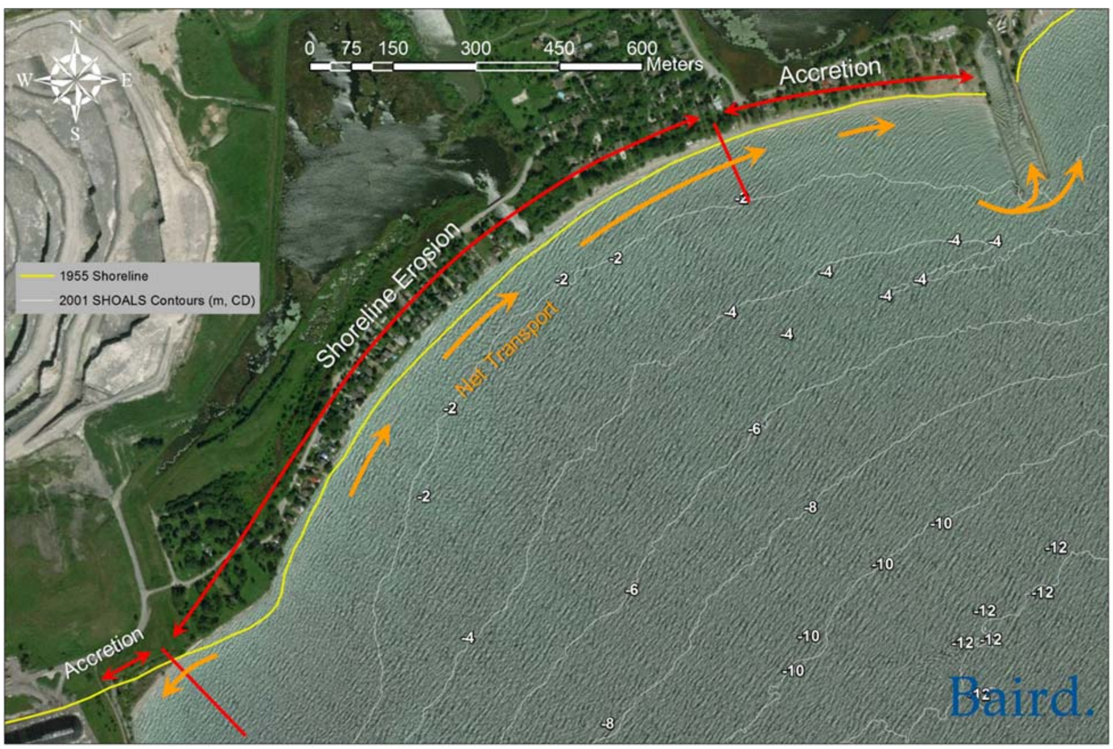

Figure 2.14: Comparison of 1955 and 2014 shorelines showing erosion and accretion areas, and net direction of longshore sediment transport

2.5 Climate Change

There have been numerous studies to investigate the potential impacts of climate change on water levels in the Great Lakes Basin (e.g. Croley, 2003; Fan and Fay, 2003; Mortsch, 2009; TRCA, 2015; Ontario Climate Consortium, 2015). These studies rely on statistical downscaling techniques which transfer the results from the Global Climate Models (GCMs) to local meteorological stations within the Great Lakes Basin. Since the GCMs generally predict hotter and dryer conditions in the future, and increased evaporation, the studies that rely on these models for the statistical downscaling predict lower lake levels in the future.

It is important to note, however, that annual and decadal cycles will continue for lake levels, even in a future influenced by climate change. Therefore, the severe swings in high and low lake levels observed in the historical record, as noted in Figure 2.12, will continue in the future. There are other potential climate change impacts that may actually increase flood and erosion risks in the future, such as decreased ice cover which exposes the shoreline to more winter storms, more intense storms and higher storm surges. There has yet to be a comprehensive study on the impacts of climate change on physical processes for Great Lakes shorelines and thus the magnitude of these other impacts are unknown. Based on these findings, a panel of experts assembled in 2009 at the Great Lakes Climate Change & Policy Workshop (Baird, 2009), recommended shoreline managers continue to rely on historical extremes for implementing coastal zone management policies. It was concluded that the historical 100-year flood level determined by MNR (1989) is still the most reliable data for use in this study.

3. Alternative Approaches to Shore Protection

3.1 Design Basis

This section presents shore protection concepts with a focus on beach enhancement, to address shoreline erosion. Based on the review of previous reports (Municipality of Clarington; 2017; Aqua Solutions, 2004; Sandwell Inc.,1990), and data, and the site visit on 6 December 2017, the area of highest concern is the shoreline in front of the properties along Cedar Crest Beach Road. The entire study area with the exception of the bluffs at the southwest end of the site, is located in the Flood Hazard from both the lake and creek sides. While some of the protection concepts may mitigate flooding due to wave uprush from Lake Ontario, they will not fully address the Flood Hazard. Overtopping and wave uprush will continue to be a concern during high water levels and the concepts do not address flooding from inland. The concepts are presented in Sections 3.2, an opinion of probable cost is provided in Section 3.3 and the concepts are evaluated in Section 3.4.

3.2 Conceptual Design Alternatives

Four concepts were developed to address shoreline erosion. Concepts 1 to 3 are integrated approaches that include development of a beach to protect the shoreline from erosion and construction of jetties at the mouth of Westside Creek and the flood drainage channel to impede sand bars from forming and obstructing flow. Through these concepts we attempt to create additional protection by maintaining beach material within the study area. They would minimize any bypassing of sediment to the east side of Port Darlington (although it is unknown if any significant bypassing is currently occurring). Alternative 4 is a traditional armourstone revetment; it does not include jetties to impede sand bar formation at the channels. The concepts, an opinion of probable costs and an evaluation of the concepts are presented in this section.

3.2.1 Concept 1: Sand and Cobble Beach with Jetties

Concept 1, shown in Figure 3.1 includes construction of a sand and cobble beach in front of the properties along Cedar Crest Beach Road. Possible sources of beach material are the sand deposit on the west side of the Bowmanville Creek jetties and the sand and cobble fillet beach east of St. Marys Cement Pier (material could possibly be excavated or dredged from these locations). These potential sources would have to be investigated during detailed design. Permits would have to be obtained for dredging operations. This is an integrated concept as it includes construction of two jetties at the mouth of Westside Creek to impede sand bars from forming at the creek mouth and obstructing flow. A jetty would also be constructed on the east side of the flood drainage channel located at the west end of the study shoreline to mitigate bar formation at the channel mouth.

This concept includes a sand and cobble beach that provides some level of protection and reduced overtopping for the properties located along Cedar Crest Beach Road, but it does not provide full protection during high water levels, particularly at the narrower west end of the beach. Monitoring and beach maintenance would be required. It is likely that there would be some transport of sand to the east, and the beach would have to be re-nourished. The frequency of maintenance would be assessed during final design, and the length of the jetties and beach width would be optimized.

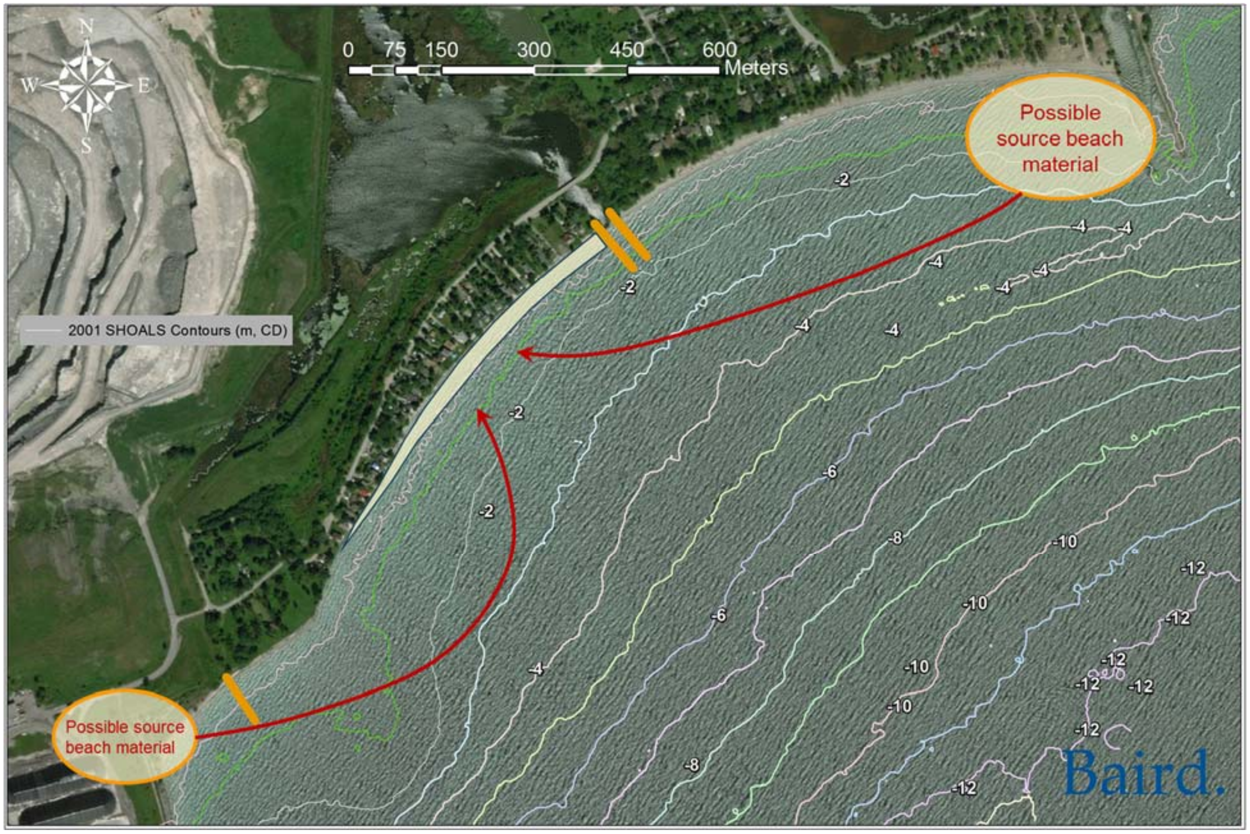

Figure 3.1: Concept 1 – Sand beach with jetties at Westside Creek and flood channel

3.2.2 Concept 2: Cobble Beach with Jetties

Concept 2, shown in Figure 3.2 is an integrated concept that includes construction of a cobble beach in front of the properties along Cedar Crest Beach Road. The fillet beach at the west end of the site may provide a source for cobble, however additional material will have to be sourced from off-site. Rounded stone is generally used and the cobble size would be determined during preliminary and detailed design. Two jetties would be constructed at the mouth of Westside Creek to impede sand bars from forming at the creek mouth and obstructing flow. A jetty would also be constructed on the east side of the flood drainage channel located at the west end of the study shoreline to mitigate bar formation at the channel mouth. In addition, two groynes would be constructed at locations along the beach, to anchor the beach and improve beach stability.

This concept includes a cobble beach that provides a higher level of protection and reduced overtopping for the properties located along Cedar Crest Beach Road than Concept 1, but it does not provide full protection from flooding during high water levels. Cobble beaches are more stable than sand beaches and the beach stability increases with larger sized cobble. In general, however, beach users prefer smaller material as it is easier to walk on. The size of cobble and beach width would be determined during final design. Maintenance requirements would be significantly lower than for Concept 1.

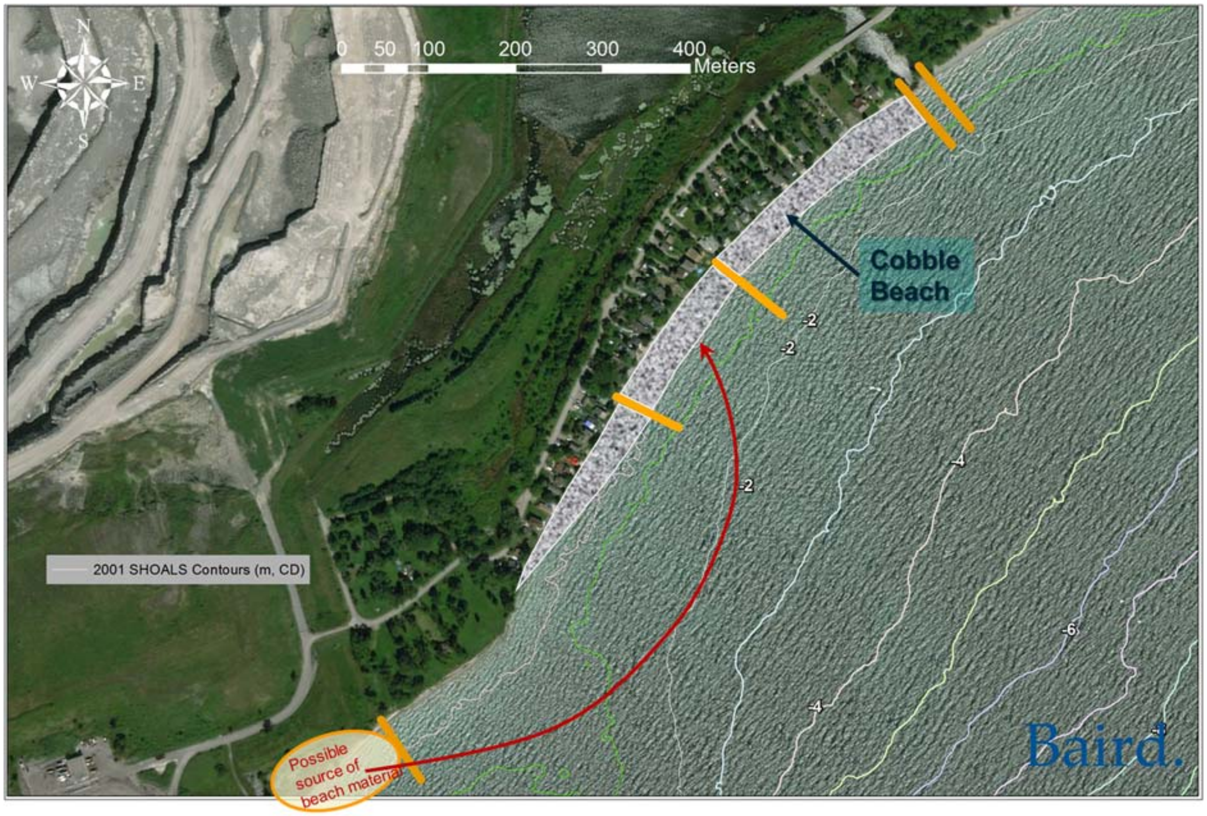

Figure 3.2: Concept 2 – Cobble beach, groynes and jetties at Westside Creek, flood channel

3.2.3 Concept 3: Sand Beach with Offshore Breakwaters and Jetties

Concept 3, shown in Figure 3.3 is another integrated concept that includes construction of a sand and cobble beach anchored with offshore rubblemound breakwaters. Possible sources of beach material are the sand deposit on the west side of the Darlington Creek jetties and the sand and cobble fillet beach east of St. Marys Cement Pier (material could be excavated or dredged from these locations). These potential sources would have to be investigated during detailed design. Permits would have to be obtained for dredging operations. The shore protection would extend along the shoreline backed by Cedar Crest Beach Road. The offshore breakwaters reduce wave energy at the shoreline and retain the beach. Two jetties would be constructed at the mouth of Westside Creek to impede sand bars from forming at the creek mouth and obstructing flow. A jetty would also be constructed on the east side of the flood drainage channel located at the west end of the study shoreline to mitigate bar formation at the channel mouth.

This concept includes the highest level of protection and reduced overtopping for the properties located along Cedar Crest Beach Road, but it does not provide full protection from flooding during high water levels. The sand beach is wider, and the offshore breakwaters provide additional protection. It is also the most costly concept presented; this is discussed further in Section 3.3. An added benefit of this alternative is the large beach amenity. Maintenance requirements would be lower than for Concept 1 and similar to Concept 2.

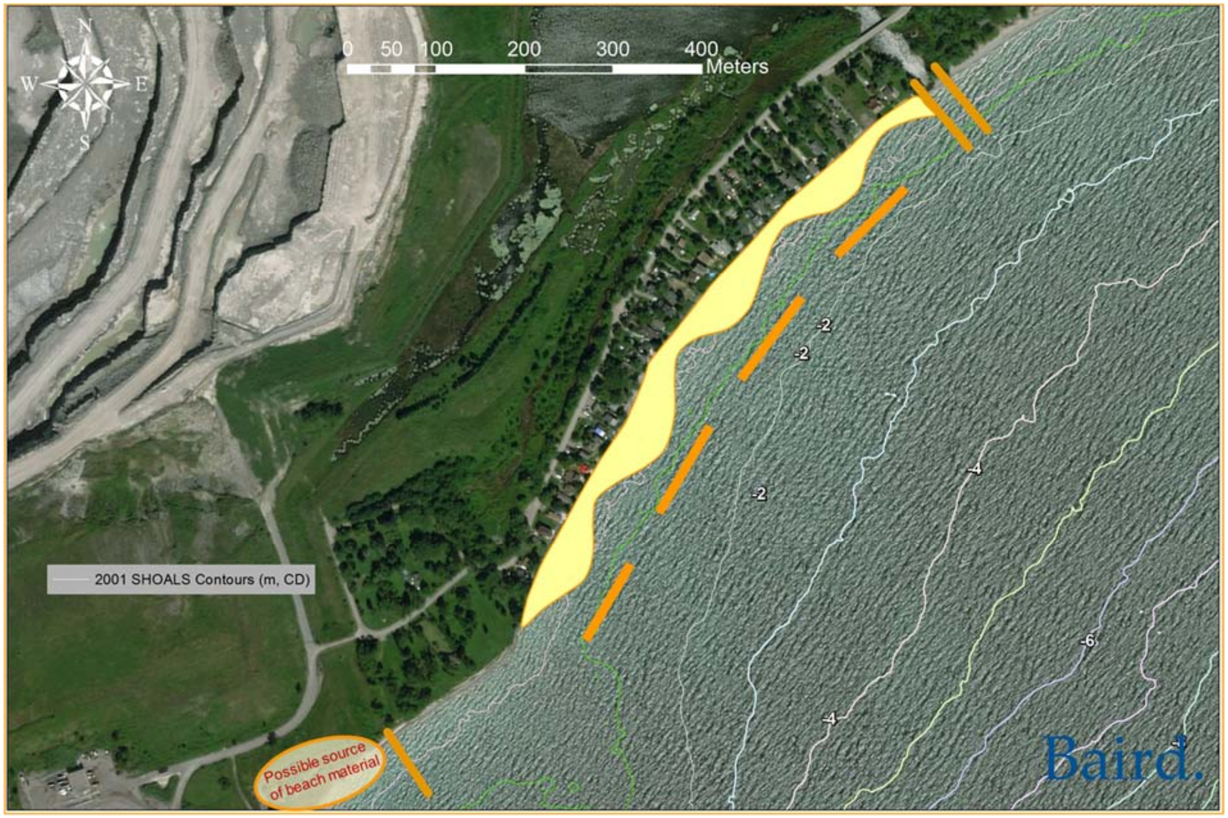

Figure 3.3: Concept 3 – Sand and cobble beach with offshore breakwaters and jetties at Westside Creek, flood channel

3.2.4 Concept 4: Armourstone Revetment

Concept 4 is an armourstone revetment; an example of an armourstone revetment is shown in Figure 3.4. The entire shoreline is currently protected by various seawalls, revetments, gabions and ad-hoc measures. Many are in a state of disrepair or are not designed to provide the required level of protection. This option would involve replacing existing structures with an armourstone revetment along the properties on Cedar Crest Beach Road. It does not include jetties to impede sand bar formation at the mouth of Westside Creek and the flood drainage channel.

This concept will mitigate further shoreline erosion, but it will do little to address flooding during high water levels. The backshore elevations are below the flood level, and the crest elevation would have to exceed the backshore elevation to address the flood hazard (e.g. runup and overtopping) from Lake Ontario. In doing so, it would trap flood water from inland (Westside Creek and Bowmanville Creek), exacerbating the inland flooding hazard.

Figure 3.4: Example of armourstone revetment

3.3 Opinion of Probable Cost

An opinion of probable cost was developed for the concepts presented in Section 3.2. Representative unit rates were determined using Baird experience; it is not uncommon for unit rates to fluctuate significantly based on project timing, demand and availability of stone, and contractor availability. The estimated capital costs for the concepts are presented in Table 3.1. These costs are concept level costs and a 30% contingency has been included. Costs for engineering, permitting, engineering services during construction, landscaping, maintenance and monitoring are not included.

Table 3.1: Opinion of probable capital cost for concepts

Concepts	Cost ($CND)	Length of Shoreline Protected (m)	Cost Per Metre of Shoreline Protected
Concept 1	$4.3 million	650	$6,600/m
Concept 2	$10.4 million	700	$14,900/m
Concept 3	$16 million	750	$21,300/m
Concept 4	$3.7 million	650	$5,700/m

The capital costs for the concepts range from $3.7 million for Concept 4 (Revetment) to $16 million for Concept 3 (Sand and Cobble Beach with Offshore Breakwaters). Maintenance costs would be highest for Concepts 1 and 4; Concept 1 does not include structures to anchor the beach, and regular beach maintenance will therefore be required; Concept 4 does not include jetties at the creek and drainage outlets and maintenance dredging will be required to maintain flow. In general, 0.5% to 1% of capital costs per annum should be budgeted for maintenance, to be undertaken periodically. The design life is typically in the range of 25 to 50 years. Maintenance requirements and design life the will vary with the wave, water level and ice conditions to which the protection is exposed.

3.4 Evaluation of Concepts

The concepts were evaluated for comparison, based on the following criteria:

- Technical and Engineering: concepts that reduce erosion and provide some protection from lake flooding are preferred. It is noted that none of the concepts fully address flooding from Lake Ontario and they do not address flooding from the creeks. Concepts that address sand bar formation at the creek and channel mouth, and thereby provide some level of mitigation for flooding from inland sources are preferred.
- Capital and Maintenance Costs – concepts with the least capital and maintenance costs are preferred.
- Socio-cultural Environment – concepts that provide opportunities for public access to the waterfront and provide a positive change to the appearance are preferred. Issues related to land ownership for new beach development are outside the scope of this study.
- Habitat Enhancement – concepts that improve the quality of aquatic and terrestrial habitat are preferred: the options were assessed based on the total area of habitat enhancement.

Each concept was ranked based on the above criteria on a scale from 1 to 3 defined in Table 3.1. The concept with the highest score performs the best considering the evaluation criteria used.

Table 3.1: Rating Definitions

Rating Score	Technical Engineering	Costs	Socio Economic	Habitat Enhancement
1	Moderate	Most	Least	Least
2	↕	↕	↕	↕
3	High	Least	Most	Most

Each concept was evaluated for the criteria listed above, using the rating scale shown in Table 3.1. The results are summarized in Table 3.2. The total rating was computed by summing up the values assigned to each evaluation criteria for each concept. The evaluation criteria were weighted equally for this process.

Table 3.2: Concepts Evaluation

Concept Options	Technical Engineering	Costs	Socio Economic	Habitat Enhancement	Total
Concept 1	1	2	2	2	**7**
Concept 2	2	2	2	2	**8**
Concept 3	3	1	3	3	**10**
Concept 4	1	3	1	1	**6**

Overall Concept 3 received the highest ranking based on the criteria evaluated. Concept 3 provides the highest level of protection against erosion and provides some reduction in flooding due to wave uprush from Lake Ontario. It is also the highest cost concept. In terms of socio-economic benefits, it provides a public beach that people can walk on. It has been assumed that habitat enhancement would be provided by or at the breakwaters, for example aquatic reefs.

Concept 2 received the next highest overall score. Concept 2 provides the second highest level of protection against erosion and provides some reduction in flooding due to wave uprush from Lake Ontario. It is the second highest cost alternative. The beach was given a mid range score; it provides a public space, but cobble beaches can be difficult to walk on, depending on the size of the cobble. On the other hand, the cobble beach effectively absorbs wave energy and reduces but does not eliminate wave overtopping during higher water levels. It has been assumed that habitat enhancement would be provided at the jetties, for example aquatic reefs.

Concept 1 received the third highest score overall. Concept 1 provides the lowest level of protection against erosion and flooding from Lake Ontario and provides limited protection at the west end of Cedar Crest Beach Road. While Concept 1 construction costs were relatively low, this concept would have high maintenance costs due to the need to nourish the beach. The beach provides a public amenity for walking; however it is smaller than the Concept 3 beach and with no structures to anchor the beach, erosion would be a concern. It was therefore given a mid range score for Socio Economic. Again, it has been assumed that habitat enhancement would be provided at the jetties, for example aquatic reefs.

Concept 4 (along with Concept 2), provides the second highest level of protection against erosion. The crest elevation of the structure would have to be designed to limit overtopping and this would be challenging considering the elevation of the land behind. A large splash pad would mitigate damage during overtopping, however this also creates a barrier to lake access. There are challenges with increasing the structure height due to the flood risk from inshore and the risk of trapping flood water from the marshes. This alternative has the lowest capital cost, however maintenance costs would be relatively high, as it does not include jetties to address the sand bars blocking flow from the creek and channel, and maintenance dredging would therefore be required to maintain flow. This concept received the lowest ranking for Socio Economic as it does not result in the creation of any public space or beach amenity. No new habitat is created with this concept.

These rankings are presented for discussion purposes. There are many different ranking systems that could be used, considering different criteria and weights that could be applied to the criteria.

4. Regulatory Approvals

This section lists permitting requirements for shore protection.

4.1 Central Lake Ontario Conservation Authority (CLOCA)

Under Ontario Regulation 42/06 Central Lake Ontario Conservation Authority (CLOCA) regulates development along Lake Ontario within the shoreline hazardous lands (flood, erosion and dynamic beach) plus an allowance of 15 m inland; this defines the Regulation Limit. The study site is also within the Regulation Limit for flooding from Westside Creek and Bowmanville Creek. A permit is required from CLOCA to undertake development within the Regulation Limit.

4.2 Fisheries and Oceans (DFO)

Authorization may be required from the Department of Fisheries and Oceans (DFO) under the federal Fisheries Act, particularly when protection measures occupy fisheries habitat. In general, it is recommended that discussions be initiated with DFO early in the project. This can be done during the concept design or preliminary design phase. Once the design development phase is complete, DFO will review and advise whether a full Authorization is required.

4.3 Ontario Ministry of Natural Resources and Forestry (MNRF)

Work along the shorelands will require a Work Permit from the Ontario Ministry of Natural Resources and Forestry (MNRF). Unless there is a water lot, or some other legal property designation giving title to the shore owner, the lakebed below the water level is Crown Land administered by MNRF.

4.4 Canadian Coast Guard

If the shoreline protection structures are proposed offshore and have the potential to interfere with navigation under the Navigation Protection Act, permission from the Canadian Coast Guard is required. this is applicable to a number of the concepts presented. If the structures are considered a navigation hazard, navigation aids will also be required.

4.5 Environmental Assessment

The Ontario Environmental Assessment requires municipalities to complete an Environmental Assessment (EA) when undertaking capital works projects. Municipalities can follow the Municipal Engineers Association's Class EA process for some projects.

5. Summary and Next Steps

5.1 Summary

Properties along the shoreline between the mouth of Bowmanville Creek and St. Marys Cement are located within the Lake Ontario flood, erosion and dynamic beach hazard limits. The Regulation Limit for flooding from Westside Creek and Bowmanville Creek also extends through these properties. Concepts have been developed to address erosion along the shoreline backed by Cedar Crest Beach Road, the shoreline with the highest erosion and overtopping rates. Some of the concepts also mitigate flooding due to wave uprush from Lake Ontario, though it is important to state that none of the concepts presented fully address the flood hazard from Lake Ontario. Neither do they address flooding from inland. An overview of sediment processes and their impact on erosion is also provided. The key findings are summarised below:

- The study shoreline is in an embayment formed between Port Darlington and St. Marys Cement pier. A comparison of shoreline location in 1955 and 2014 based on historical and recent satellite imagery shows the highest recession rates along Cedar Crest Beach Road. From West Beach Road eastward the shoreline has accreted over the period of comparison.
- The net longshore sediment transport is in an easterly direction from the bluff at the west end of the study area to the Bowmanville Creek mouth; and in a westerly direction from the bluff to St. Marys Cement. This is demonstrated by the fillet beaches that have formed at either end of the study shoreline.
- On the day of the site visit, a sand bar had deposited at the mouth of Westside Creek and the flood discharge channel at the west end of the study area. This is reportedly not uncommon and the bar at Westside Creek was dredged in the summer of 2017 to allow the creek to discharge and mitigate flooding from inland.
- Four shore protection concepts were developed with a focus on the development of a beach amenity that also protects the shoreline from erosion and mitigates wave overtopping. A concept level opinion of probable cost was developed for each concept. The concepts were then evaluated on the basis of technical, cost, socio-economic impacts and environmental impacts.
- The capital costs for the concepts ranged from $16 million for Concept 3 which includes a sand beach anchored with offshore breakwaters, and jetties to mitigate sedimentation at the mouth of Westside Creek and the overflow channel; to $3.7 million for Concept 4, an armourstone revetment. These are equivalent to $21,300/metre for Concept 3 and $5,700/metre for Concept 4.
- Concept 3 received the highest ranking overall, based on the criteria evaluated. Concept 3 provides the highest level of protection against erosion and provides some reduction in flooding due to wave uprush from Lake Ontario. It is also the highest cost concept. In terms of socio-economic benefits, it provides a public beach that people can walk on. It has been assumed that habitat enhancement would be provided at the breakwaters, for example aquatic reefs.
- The rankings are presented for discussion purposes. There are many different ranking systems that could be used, considering different criteria and weights that could be applied to the criteria.
- Out of the four concept designs, Concept 3 provided the highest benefit when considering the evaluation criteria. Concept 2 was a close second, while Concept 1 ranked third and Concept 4 ranked fourth.
- It is emphasized that the concepts presented do not fully protect the shoreline from flooding from Lake Ontario; during high water levels overtopping will occur. Nor do they provide any protection from flooding from inland creeks.

5.2 Next Steps

Decisions will need to be made by the parties involved, regarding the costs and benefits of providing erosion protection for a shoreline that is located within the Lake Ontario flood hazard, and the flood hazard from Bowmanville Creek and Westside Creek.

In the event that a decision is made to proceed with erosion protection at the site, meetings can be held to discuss the concepts and funding partnerships. Variations of these concepts might also be considered. An Environmental Assessment would be required for this project. Under the EA process, numerical modelling would be used to confirm the performance of the selected alternative and to refine the design. Drawings and specifications would be developed during detailed design. Once the preparation of detailed design documentation is complete, application(s) can be submitted to regulatory agencies for review. It is recommended that regulatory agencies are contacted during preliminary design.

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