THE IMPACT OF EXTREME WATER LEVELS ON TORONTO ISLAND PARK AND INCREASING RESILIENCE AGAINST FUTURE FLOOD EVENTS

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BACKGROUND

Toronto Island Park is a chain of fifteen low-lying islands in Lake Ontario located just south of the Toronto shoreline in Ontario, Canada. The Park serves as a popular year-round urban attraction of significant economic importance, and showcases unique natural features, cultural heritage, and sensitive ecosystems. The Park is home to Billy Bishop Airport, Centreville Amusement Park, numerous small businesses, and over 250 residential homes.

In recent years, the Toronto Islands have suffered significant physical and economic impacts due to flooding caused by extreme wet weather and record high water levels on Lake Ontario. In 2017, daily average lake water levels at Toronto were the highest recorded since data collection began in 1918 and remained above the 100-year flood level for two months in the summer. The sustained period of high water levels forced shut downs of island businesses, amenities, and the amusement park and also restricted ferry access, resulting in approximately $8M in direct and indirect damages. Emergency measures were implemented by the Toronto and Region Conservation Authority (TRCA), the City of Toronto, and the Island residents to mitigate flood damage. Existing shoreline structures are aging and were not designed to an elevation that could handle the record lake levels, and as such, were overtopped. The Park was once again subject to flooding in 2019 when water levels on Lake Ontario exceeded the previous 2017 record by 10 cm. Lessons learned from the 2017 event aided in the preparation and execution of temporary flood measures during the 2019 event; however, a long-term solution to island flooding is required.

In 2021, Baird was retained by TRCA to develop long-term flood and erosion mitigation concept alternatives to replace temporary and emergency measures and to increase the functionality and resilience of the flood control infrastructure on the islands. This abstract outlines the various concept alternatives that were considered, the public engagement process and resulting preferred concepts for flood mitigation.

CLIMATE CHANGE IMPACTS

Recent climate change research suggests that the pattern of increased precipitation and evaporation and extreme high and low water levels observed over the past few decades on the Great Lakes will continue, and that the range and variability of water levels are expected to expand with greater possibility of extreme highs and lows in the future (Seglenieks, 2022). For the Toronto Islands, this may result in increased frequency and severity of flood events.

Currently, the majority of the Toronto Islands shoreline, which totals approximately 13 km, is protected by seawalls, jetties, revetments and groynes. However, many of these structures are not sufficient to mitigate flooding during periods of extreme water levels on Lake Ontario.

Figure 1 – Flooding along Cibola Ave. in the Toronto Island Park during the 2019 flood event. (Source: TRCA).

STUDY AREAS

The project focuses on the development of flood protection alternatives for four high priority areas within the Park, as indicated in Figure 2: Ward's Island, Algonquin Island, Centre Island and Roadways throughout the Park. These areas were identified through site observations, knowledge of heavily impacted areas during the 2017 and 2019 flood events, land use mapping, and flood depth mapping. Ward's Island and Algonquin Island are the primary residential areas within the Park. There is an existing public beach and ferry dock on Ward's Island. The majority of Algonquin Island is residential. The south end of Algonquin Island includes the Algonquin Island Association Clubhouse (Clubhouse) and Provincially Significant Wetland and Woodland, and the north end of the island is occupied by the Queen City Yacht Club (QCYC). Centre Island is the central tourist area and recreational area of the Island Park. The Centre Island study area includes three sub-focus areas: Centreville Amusement Park, Centre Island Ferry Dock and the Toronto Island Marina. The Roadways study area includes 5.5 km of vulnerable roadways throughout the islands that would be flooded with a depth of 10 cm or more during the 100-year flood event.

DESIGN CONSIDERATIONS

As part of the 2019 flood study, Baird completed modeling and analyses of water levels and wave conditions for both the exposed lake and sheltered harbour shorelines, including consideration of changes to the Lake Ontario regulation plan that were implemented in 2017. The resulting estimate of the 100-year flood level (76.2 m IGLD85) is 0.4 m above previous design standards for the region and was used in the development of concept design alternatives.

Figure 2 – Location of study areas on Toronto Island Park.

The development of concept designs considered existing site characteristics, particularly shoreline exposure, water depths, elevation and condition of existing shoreline protection, environmental impacts and opportunities, current and future park users and amenities, functional performance, constructability, and cost. The resulting concept alternatives include a range of traditional hard-engineered structures, innovative "softer" approaches which incorporate nature-based features, and multi-functional shoreline treatments that provide ecological and recreational benefits.

Concepts developed for various shorelines within the study areas include impermeable flood berms, steel sheet pile flood walls, concrete flood walls, land raising, naturalized shorelines and nearshore habitat creation, and modular flood walls. To mitigate flooding on the roadways, four concepts were developed that involved raising the elevation of the road above the 100-year flood level. These four concepts considered use of various impermeable materials to prevent flow of water beneath the roads and protective measures to resist washout during a flood event.

The flood protection concepts are being developed in coordination with the development of an updated Toronto Island Park Master Plan. Where possible, flood mitigation concepts are coordinated with the master plan goals. Opportunities for multipurpose shoreline treatment have been identified and will be explored further during detailed design. Examples of identified opportunities include incorporating multi-use recreational pathways along the top of a flood berm, addition of beaches at Ward's Island, and creation of nearshore habitat along Algonquin Island to provide additional recreational areas, fishing opportunities, and water access for non-motorized watercraft.

PUBLIC ENGAGEMENT

The project is following a Class Environmental Assessment (EA) for Remedial Flood and Erosion Control Projects, which is a planning framework/undertaking that is provincially designated under the Environmental Assessment Act. Concept alternatives were evaluated against their ability to address flood and erosion hazards, environmental impact, social and cultural value, technical criteria, constructability, financial cost and public safety.

Concepts were presented to the public and stakeholders for review and feedback as part of the public engagement process. Stakeholders included Island businesses, residents, local community groups and Indigenous communities. Representatives from partner and jurisdictional planning agencies were also consulted, including various City of Toronto departments, emergency response services, and local waterfront improvement agencies. Feedback from the public and stakeholder engagement was incorporated into the evaluation of concept alternatives and selection of the preferred concepts.

PREFERRED CONCEPTS

The preferred concept for Ward's Island includes an impermeable berm with a groyne and sand fill to expand the existing beach east of the Ward's Island ferry dock. The expanded beach area provides additional recreational benefits and reduces wave runup. The impermeable berm increases the crest elevation of the shoreline, thus providing flood protection to the residential area, and is protected by rip rap to provide erosion protection and reduce wave run-up.

The preferred concept for Algonquin Island includes a vegetated inland flood berm along the south shoreline of the island, built up nearshore habitat and flood berm along the northwest shoreline and a modular flood wall around QCYC. The location of the inland berm along the southern shoreline was optimized to reduce impacts to the ecologically sensitive area while providing flood protection to the Clubhouse and surrounding area. The nearshore habitat along the northwest shoreline includes placement of fill in front of the existing steel sheet pile wall with aquatic habitat features such as woody debris, rock shoals and aquatic plants. This increases the complexity/diversity and quality of the nearshore habitat and will also provide some level of wave attenuation, thereby reducing wave runup. The nearshore habitat area will be backed by an impermeable flood berm located along the existing shoreline with an increased crest elevation to accommodate the 100-year flood elevation plus wave runup. The modular flood wall for QCYC includes installation of spaced posts around the club shoreline. Timber boards would be dropped in place between the posts to create a flood wall during a flood event. This concept alternative works in tandem with flood mitigation measures already completed by QCYC members who have constructed a raised walkway/berm and modular flood wall around the east shoreline of the club.

The preferred concept for Centreville is a flood berm with a naturalized shoreline. Around the Centre Island Ferry Dock, the preferred approach is a combination of a stepped/ stacked armour stone wall backed by an impermeable flood berm and a stepped concrete flood wall. The stepped/ stacked wall increases the crest elevation of the shoreline, providing flood protection during periods of high water and offers additional seating and views of the City mainland for park users. The preferred alternative for the Toronto Island Marina includes raising the roads and lands within the central area and boat storage yard. The stretch of shoreline between the marina and the ferry terminal will be protected with an impermeable flood berm along the shoreline. The lakeward slope of the flood berm will include nature-based features including vegetation and stone to provide erosion and wave run up protection and improved shoreline habitat.

The preferred concept for raising the roadways includes an impermeable shoulder created by capping the granular base course (roadway fill) with low permeability clay. The centre of the road will be raised above the 100-year flood level to a minimum elevation of 76.25 m. This design has already been implemented along several roadways on the island as part of emergency road raising works that were completed following the 2019 flood.

NEXT STEPS

A detailed environmental analysis is being completed for the preferred designs to predict the net impact of implementation and to identify appropriate mitigation measures as needed. The preferred alternatives and results of the study will be presented to the public and stakeholders in the fall of 2022 for a second round of public engagement. The results of this analysis will be compiled into an Environmental Study Report (ESR) as part of the Class EA process. Following the ESR and completion of the Class EA process, the project will proceed to detailed design and permitting phase for priority sites. Construction works will be phased based on site priority and will be subject to funding availability.

REFERENCES

Seglenieks (2022): Climate and Lake-level Changes in the Great Lakes Basin, Environment and Climate Change Canada, Presentation at the Great Lakes Coastal Wetlands Webinar Series.