Item 8.1

Section I – Items for Board of Directors Action

TO: Chair and Members of the Board of Directors
Meeting #9/19, Friday, October 25, 2019

FROM: Sameer Dhalla, Director, Development and Engineering Services

RE: **FLOOD RISK ASSESSMENT AND RANKING RESULTS**

KEY ISSUE

This report summarizes the process and results of TRCA's Flood Risk Assessment and Ranking study, a National Disaster Mitigation Program project which quantified and ranked risk across the 41 flood vulnerable clusters in TRCA's jurisdiction.

RECOMMENDATION

WHEREAS TRCA received approval to pursue funding for flood risk mitigation projects through the National Disaster Mitigation Program (NDMP) at meeting #6/16, held on July 22, 2016;

WHEREAS TRCA staff were requested to report back to the Board of Directors in 2018 and 2020 to provide a summary of the work that has been completed with funding from the NDMP;

AND WHEREAS TRCA resolved that staff be directed to continue to work with municipal staff and the insurance industry to share information from NDMP projects to advance and improve flood communications at meeting #6/19, held on June 21, 2019;

THEREFORE, LET IT BE RESOLVED THAT this report, outlining the process, methodology, and ranking of flood vulnerable clusters as part of the Flood Risk Assessment and Ranking Project be received;

THAT staff continue to work with municipal partners to utilize this information in flood response planning and to prioritize flood mitigation and remediation efforts;

THAT TRCA staff, together with municipal partners, pursue opportunities to pro-actively share important flood risk information with residents living in flood vulnerable areas, through measures including dedicated open houses hosted in conjunction with partner municipalities, as well as informational mail-outs that direct them to neighbourhood-specific web content

AND FURTHER THAT the Clerk and Manager, Policy, so advise municipal partners, Conservation Ontario and the Ministry of Natural Resources and Forestry.

BACKGROUND

Over 3.5 million people live within the watersheds that make up TRCA's jurisdiction. With drainage areas ranging from 38 square km for the Carruthers Creek to 900 square km for the Humber River, all of TRCA's watersheds are relatively small. These compact drainage areas, with highly urbanized (impervious) surfaces, and short stream lengths, leave little lead time between rainfall and flood impacts. Year-round flood threats include ice-jams in the winter,

snowmelt in spring, unpredictable thunderstorms in the summer, and hurricane remnants in the fall.

While land use planning has effectively reduced risk in new greenfield development areas, many neighbourhoods were historically settled near rivers prior to floodplain management. In other places, spills from altered watercourses and floodplains extend into populated areas. Through the course of floodplain mapping preparation, TRCA staff had previously identified numerous roads and buildings located within the regulatory floodplain, which is defined as the greater of Hurricane Hazel or the 100-year storm scenario. An original database of these flood vulnerable structures and road segments was compiled in the early 2000s. While the database considered flood events up to the regulatory storm, many of these locations would still experience flooding conditions under less extreme storm events, presenting significant risk to people and property through flood damages. Areas with a high concentration of structures in the floodplain were grouped together as Flood Vulnerable Clusters (FVCs), also known as Flood Vulnerable Areas (FVAs). Many of these areas correspond to historical Flood Damage Centres and provincially designated Special Policy Areas, where development occurred near rivers prior to land use planning for hazard mitigation and section 28 permitting regulations under the CA Act.

The Flood Risk Assessment and Ranking (FRAR) project was a multi-objective endeavor that leveraged $195,000 in funding under the Risk Assessment stream of the initial intake of the National Disaster Mitigation Program. This project enabled the acquisition of high-resolution LiDAR (Light Detection and Ranging) topographic data and Municipal Property Assessment Corporation (MPAC) data to update the database of flood vulnerable structures and roads. This project also utilized the latest flood vulnerability research to quantify flood risk at a granular level. Seeking the best available expertise in the flood risk assessment field, TRCA retained IBI Group to complete the risk assessment project, as noted in Resolution RES.#B126/17 at Executive Committee Meeting #11/17.The resulting hazard, exposure, and vulnerability data were combined together with stakeholder input and expert research, in order to rank the risk in TRCA's 41 Flood Vulnerable Clusters. The future use of this information to support projects in flood mitigation, risk communication, and emergency planning was envisioned at the outset.

Capital projects for flood mitigation typically target areas where either a significant reduction to flood damages can be achieved, or where the provision of flood risk reduction generates opportunities for community revitalization. This project can help focus remediation and mitigation efforts where maximal benefits will be realized. The average annualized flood damages that can be avoided through capital projects is already being used to inform return on investment (ROI) calculations for federal funding applications. Furthermore, the geospatial mapping products that were developed as part of this project are becoming the basis of site-specific flood emergency response plans.

METHODOLOGY

Risk is often defined as the product of probability and consequence. In natural hazard management, the more nuanced understanding of risk is achieved by combining information on the hazard (e.g.: flooding and its inherent probability), the exposure (what is in the way of the hazard), and the vulnerability (how severely the hazard impacts the asset or person exposed). The FRAR project utilized these typical components of a risk model, as outlined in Figure 1.

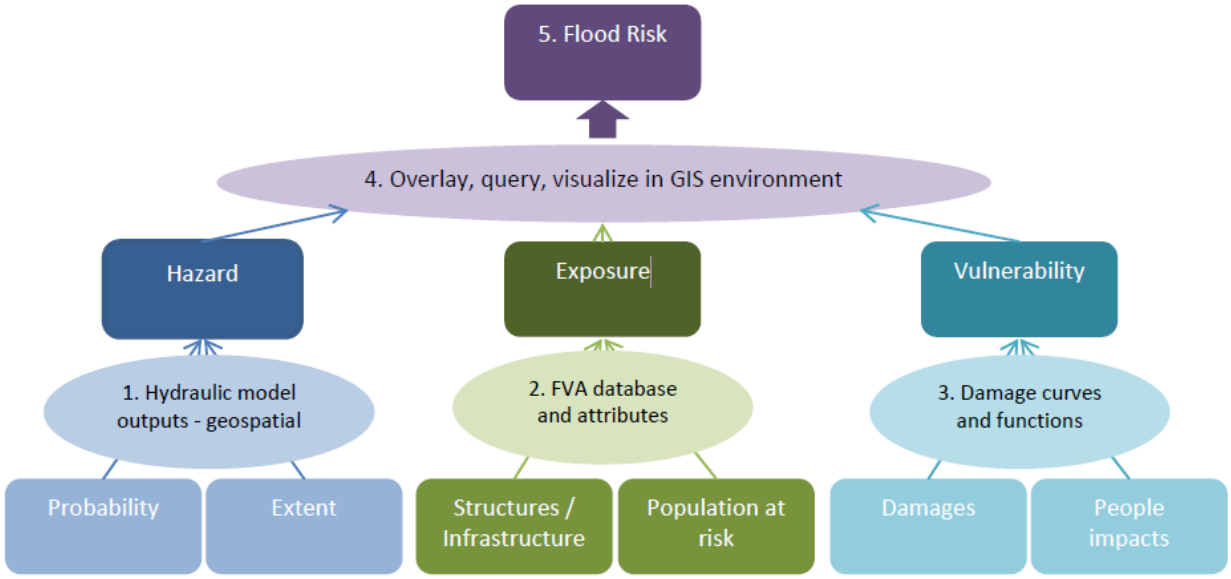

Figure 1 - Risk Model Components

Hazard
TRCA has maintained flood hazard information for different return period (i.e. 2-year through to 350-year) storm events, as well as Hurricane Hazel, within the hydraulic models used in the preparation for floodplain mapping. The FRAR project utilized the latest available model for each cluster as of July 2018. For many of the clusters, the water surface elevation, flood depth, and flow velocities were recorded in the model files but were not converted to geospatial products. As part of this project, inundation mapping, as well as depth and velocity grids, were produced from the model information for each storm. These layers were used to determine the reference flood depths for each road segment and each building (relative to the first floor) for each of the different storm scenarios. To reduce similar data processing in future updates, the provision of flood elevation, depth, and velocity information in a geospatial format has become a standard deliverable of floodplain mapping projects as of 2017.

Exposure
As part of the FRAR project, staff in Flood Risk Management and GIS updated the database of flood vulnerable buildings and roads. Over 9,000 buildings and 1500 road segments were found to be within the Regulatory floodplain. By combining available GIS data with Municipal Property Assessment Corporation and Environics data, then verifying the data with a custom, Google Earth street-level tool, over 25 different attributes for each structure were collected, including first floor elevations and structure classifications to apply the correct depth-damage curves. For mixed-use buildings, fields to distinguish upper-level and ground-level uses were also incorporated.

Vulnerability
Previous assessments of flood damages relied on Ministry of Natural Resources and Forestry depth-damage curves, which stemmed from studies undertaken in Fort McMurray over 30 years ago and which were known to contain errors that miscalculated industrial damages. As TRCA was one of the early adopters of risk assessment projects under the NDMP program, staff investigated a variety of available damage estimation methodologies at the outset of the project,

including Hazus and HEC-FIA (Hydraulic Engineers Corps – Flood Impact Assessment). Considering the need to quantify tangible damages at a granular scale (structure-basis), with methodology appropriate to Canadian urban typologies, staff identified the suitability of the new damage curves developed in 2014 for the Alberta Provincial Flood Damage Assessment Study. Simultaneously and in parallel to the FRAR project, these functions were endorsed in the Guidelines and Database of Flood Vulnerability Functions by Natural Resources Canada. In addition to providing thought leadership to other conservation authorities and municipal partners who are now following similar processes, TRCA undertook the task of indexing the Alberta curves to account for construction and household price differences in Ontario. The indexed curves have been broadly shared with partners and other organizations in the risk assessment realm.

Damage Estimation and Risk Ranking

The FRAR project considered measures of risk that were both tangible and intangible, and both direct and indirect. Tangible damages are those damages that can be quantified in dollar values. Tangible damages can be direct or indirect; direct damages are the result of floodwaters, while indirect damages are the result of additional expenses incurred or productivity lost because of the flood. Examples of tangible direct damages include the cost of repairing a flooded basement and replacing the contents. Examples of tangible indirect damages include the cost of alternate accommodation while the home is flooded. Tangible damages were calculated for each structure, and these values were summed to inform the tangible damage scores for each cluster.

Intangible damages are those that cannot be quantified as dollars. They can, however, be described and compared. Intangible factors were calculated on a cluster basis. While there may not be a dollar value for these factors, each factor was given a score based on relative metrics.

The final risk ranking matrix, including the relative weighting of each category, was developed by IBI based on governing best practices, availability of data, and a stakeholder input workshop held in the summer of 2018. Flood damage estimates within the FRAR project were undertaken to provide an even comparison of flood impacts across TRCA's jurisdiction, as opposed to reaching a conclusion on the economic impact of flooding. They represent synthetic scenarios, and some categories of impact (e.g. buried infrastructure) were not assessed due to data limitations. It is therefore important to note that the methodology favors consistency over perfect accuracy and that the scale of impact analysis is at the structure and neighbourhood level – secondary impacts to the municipality at-large were not assessed at this time. The final risk matrix considered factors in the following four categories.

1. Building-related tangible damages, which include structure and content damages, loss of revenue due to business interruption, and cost of residential displacement, each of which were calculated as dollar values using depth-damage curves. This category accounted for 50% of the total risk score.

2. Community impacts, which takes into consideration institutional buildings that provide critical community functions such as emergency services, schools, cultural and religious buildings, community associations and indoor recreation facilities. This category accounted for 10% of the total risk score.

3. Social vulnerability, which counts the total affected population and indexes the population based on five demographic factors which potentially increase flood

vulnerability, namely: age, family-type, income, housing tenure, and proximity to hospital facilities. This category accounted for 20% of the total risk score.

4. Disruption to infrastructure, which focuses on overall depth of flooding on roadways, as well as the number of impassible road segments, both weighted by road class. A placeholder for utility disruption was included but was not calculated due to data limitations. This category accounted for 20% of the total risk score.

A future placeholder for preparedness and resiliency, which could reduce the risk score, was included for future projects which might compare to the baseline scenario.

The variables that were used to assess vulnerability for each of the four categories were quantified for each return-period storm event. Damage-probability curves were plotted for the variables, and the area under the curve yielded the average-annual damage/vulnerability for each variable. This essentially weights the damages according to the probability of them occurring. Through this method, damages from a more frequent event would add more to the average annualized damage than from an infrequent event. Utilizing average annualized damages incorporates both likelihood and consequence to allow for a fair comparison of flood risk between clusters.

RATIONALE

Based on the methodology described above, the following is the ranking of flood vulnerable clusters in TRCA's jurisdiction. Because the Toronto Islands flood from Lake Ontario, which is a different mechanism than riverine flooding, it is not ranked in Table 1, although it did undergo a similar risk assessment process modified to appropriately consider the park impacts. It is also important to note that the risk ranking process does include the benefits of flood control structures (such as dams) as they currently function, but does not include the additional risk of infrastructure failure. Infrastructure risk analysis and dam safety reviews are undertaken as separate projects on a structure-by-structure basis.

TRCA and municipal partners are actively undertaking flood remediation projects that either reduce existing flood risk in a number of the clusters below, or create opportunities for community revitalization. It is important to recognize that structural remediation approaches are not always possible in some areas; non-structural approaches such as emergency planning, risk communication, and enhancements to flood forecasting and warning measures continue to be pursued. The full scores and rankings within each category can be found in Attachment 1, while Attachment 2 depicts a map of the clusters, and Attachment 3 provides summary factsheets for each cluster.

Table 1 – Risk Rankings of Flood Vulnerable Clusters

Cluster Rank	Cluster Name *(denotes a portion of the cluster is a Special Policy Area)	Municipality	Related Projects (TRCA or Municipal)
1	Rockcliffe *	Toronto	Black Creek at Rockcliffe Special Policy Area Flood Remediation and Transportation Feasibility

Cluster Rank	Cluster Name *(denotes a portion of the cluster is a Special Policy Area)	Municipality	Related Projects (TRCA or Municipal)
			Study; site-specific flood response plan
2	Jane/Wilson *	Toronto	Target area for site-specific flood response planning and community outreach
3	Dixie/Dundas*	Mississauga	Dixie-Dundas Flood Mitigation Strategy; site-specific flood response planning
4	Pickering Village*	Pickering/Ajax	Rehabilitation of the Pickering and Ajax Flood Control Dykes Class Environmental Assessment
5	Bolton Core*	Caledon	Bolton Berm Major Maintenance Project; site-specific flood response planning
6	Avondale / Spring Creek*	Brampton	Central Area Integrated Flood Modelling and Infrastructure Assessment; target for site-specific flood response planning and outreach
7	Progress Business Park	Toronto	Highland Creek Markham Branch Flood Protection EA
8	Lower Don*	Toronto	Port Lands Flood Protection Project
9	Lake Wilcox*	Richmond Hill	Target for site-specific flood response planning
10	Markham Industrial	Markham	Don Mills Channel Project; outreach target
11	Brickworks	Toronto	Existing site-specific response plans

Cluster Rank	Cluster Name *(denotes a portion of the cluster is a Special Policy Area)	Municipality	Related Projects (TRCA or Municipal)
12	Thornhill	Vaughan	Municipal stormwater improvements
13	Kennedy Commons	Toronto	Under review
14	Edgeley/Vaughan Centre	Vaughan	Black Creek Renewal Municipal Class EA
15	Ionview	Toronto	Under review
16	Albion Road	Toronto	Under review
17	Dorset Park	Toronto	Under review
18	Maple	Vaughan	Under review
19	Bay Ridges	Pickering	Krosno Creek Flood Reduction Study
20	Woodbridge*	Vaughan	Under review
21	Unionville*	Markham	Target for site-specific flood response planning
22	Malton	Mississauga	Malton Flood Characterization Study
23	Keele Industrial	Vaughan	Under review
24	Newkirk Business Park	Richmond Hill	Under review
25	Hoggs Hollow*	Toronto	Dam Emergency Preparedness Plan recently completed
26	Stouffville Centre	Stouffville	Stouffville Dam Feasibility Study
27	New Westminster	Vaughan	Under review
28	Brampton Central*	Brampton	Downtown Brampton Flood Protection Project EA
29	Vellore Woods	Vaughan	Under review

Cluster Rank	Cluster Name *(denotes a portion of the cluster is a Special Policy Area)	Municipality	Related Projects (TRCA or Municipal)
30	Willowfield	Toronto	Under review
31	Dundas West	Toronto	Under review
32	Lower Carruthers	Ajax	Target for site-specific emergency response planning
33	Little Etobicoke	Mississauga	Little Etobicoke Creek Flood Evaluation Study and Master Plan
34	West Mall*	Mississauga/Toronto	Under review
35	Longbranch	Toronto	Under review
36	Elgin Mills	Richmond Hill	Municipal Class Environmental Assessment Flood Remediation Study Yonge Street and Elgin Mills Road - Flood Vulnerable Area
37	Old Markham Village	Markham	Under review
38	Concord	Vaughan	Under review
39	South Mimico	Toronto	Under review
40	Altona/Rougemount	Pickering	Under review
41	Langstaff Business Park	Vaughan	SNAP Project

Municipal Partner and Public Outreach

TRCA hosted workshops in early June to share the results of this study with municipal partner staff and engage them in associated projects. In addition to determining damage estimates and risk rankings, the significant data collection associated with this study has provided valuable information that has already been used in emergency response scenarios. To leverage the multi-functional outputs of this project, TRCA subsequently received NDMP funding through intakes 4 and 5 to undertake targeted public outreach in flood vulnerable clusters, and to develop tools and processes for Site Specific Flood Response Plans. Two workflows from this project have already been used in actual flood emergencies. The methodology for intersecting building and floodplain layers in GIS was utilized for the response maps for Lake Ontario in 2017 and 2019, and the structure database was used to generate address lists to support the Town of Caledon, Region of Peel and Ontario Provincial Police evacuation efforts during the Bolton Ice Jam in March 2019.

Global and local best practices for flood risk reduction cite the importance of risk communication to people who live and work in flood prone areas. Effective risk communication in advance of an emergency is essential to ensuring appropriate crisis communication during an emergency. There are numerous actions that homeowners, employers, and tenants can take in order to reduce the impact of flooding. Having an updated and enhanced understanding of risk in flood-prone areas, TRCA staff have been working on a targeted public outreach program for flood vulnerable clusters, which includes dedicated web content, informational mail-outs, and in-person open house sessions. Where possible, TRCA is working together with partner municipalities to undertake these projects.

Relationship to Building the Living City, the TRCA 2013-2022 Strategic Plan
This report supports the following strategies set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 2 – Manage our regional water resources for current and future generations
Strategy 8 – Gather and share the best sustainability knowledge

FINANCIAL DETAILS
The Flood Risk Assessment and Ranking study was completed using funds provided by the National Disaster Mitigation Program, City of Toronto, and the regional municipalities of Peel, York and Durham. Funding was allocated in account 107-09.

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Attachments: 3

Attachment 1: Total and Category Risk Scores for TRCA Flood Vulnerable Clusters
Attachment 2: Map of Flood Vulnerable Clusters
Attachment 3: Cluster Factsheets