Item 8.4

Section I – Items for Board of Directors Action

TO: Chair and Members of the Board of Directors
Meeting #6/20, Friday, September 25, 2020

FROM: Sameer Dhalla, Director, Development and Engineering Services

RE: **SUMMARY OF RECENT UPDATES TO TRCA FLOOD PLAIN MAPPING PROGRAM**

KEY ISSUE

Toronto and Region Conservation Authority's (TRCA) flood plain maps are a key technical output necessary to fulfilling TRCA's mandate and specific TRCA's Strategic Plan objectives to reduce flood risks and protect communities. Flood plain mapping and the associated studies are the foundation of several programs within TRCA, including flood forecasting and warning, and land use planning and regulation. Leveraging National Disaster Mitigation Program (NDMP) funding, TRCA Engineering Services has completed a comprehensive, jurisdictional wide, flood plain mapping update over the past five years.

RECOMMENDATION

THAT this report, with the associated flood plain mapping available online, be received;

THAT Toronto and Region Conservation Authority (TRCA) staff be directed to communicate to municipal partners and stakeholders the results of TRCA's recent flood plain mapping updates and studies;

THAT this report be circulated to TRCA's municipal and government partners and stakeholders;

AND FURTHER THAT staff be directed to report to the Board of Directors when future comprehensive flood plain mapping updates are completed.

BACKGROUND

The *Conservation Authorities Act* (CA Act) provides the legal basis for TRCA's mandate to undertake watershed planning and management programs that prevent, eliminate, or reduce the risk to life and property from flood and erosion hazards. TRCA undertakes flood plain mapping under the responsibility given to it by Section 28 of the CA Act and TRCA's corresponding Regulation: Ontario Regulation 166/06, as amended (Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses).

Flood studies and flood plain mapping are prepared and approved for TRCA by qualified Water Resource Engineers using standards and criteria established by the Ontario Ministry of Natural Resources and Forestry (MNRF).

Flood plains are determined based upon information gathered through flood plain mapping studies, which is analyzed and synthesized as part of a flood plain mapping update. Flood plain mapping studies are technical reports that use topographic data, surveys of infrastructure such as the size of bridges and culverts, land use information, weather data, stream flow data, and detailed hydraulic and hydrologic models (as outlined below) of each watershed in order to

determine the spatial extent of a flood plain. The flood plain boundaries are shown on detailed topographic maps.

Since its inception, TRCA has undertaken a number of jurisdictional wide flood plain mapping updates to ensure floodlines and regulation mapping remain current and reflective of each watershed's landscape. Flood plain mapping updates leverage technological advancements in mapping products, modelling capabilities, staff resources and expertise, and monitoring data.

TRCA's first comprehensive flood plain mapping update took place in the 1960s. It was undertaken for the purposes of meeting the requirements of Ontario Regulation 253/64 for regulating the construction of buildings or structures in areas below the high-water mark of rivers, creeks or streams; and regulating the placing or dumping of fill of any kind in areas defined by the Authority. It should be noted that the term "below the high-water mark of rivers, creeks, or streams" was in reference to the fact that floodlines at the time were based on recorded high-water marks collected after the Hurricane Hazel event for each watershed. Where water marks were not available, floodlines were based on manual hydrology and hydraulic calculations.

The next comprehensive flood plain mapping update occurred when federal funding becoming available as part of the 1975 National Flood Damage Reduction Program (FDRP). The FDRP was intended to coordinate federal and provincial strategies through defining flood risk areas, by discouraging continuing development in those areas, and by following up with appropriate measures to limit damage to existing development. Flood plain maps were subsequently updated in the early 1980s using analog base-mapping and first-generation hydrology and hydraulic modelling software. This project was completed in 1987 coinciding with the Ontario Regulation 193/86 update, regulating the construction of buildings or structures, the placement or dumping of fill, and the alteration of watercourses in the Metropolitan Toronto Region.

In the early 2000s, TRCA initiated the third comprehensive flood plain mapping update. Leveraging funding from our municipal partners TRCA was able to modernize the program moving away from analog base mapping into a digital environment using modern computer modelling software to establish floodlines. The intent of this comprehensive flood plain mapping update was to convert analog base mapping into a digital format, ensuring both mapping and modelling updates resulting from development applications could occur in real time. The floodlines developed through this flood plain mapping update were one of the criteria for TRCA's Regulation Limit (Ontario Regulation 166/06), regulating construction, alteration and development activities in and around valleys, streams and wetlands and along the Lake Ontario shoreline.

Historically, flood plain mapping updates have been critical for supporting municipal implementation of provincial legislation and policies for managing flood risk through TRCA roles and responsibilities in development and infrastructure planning. However, flood plain maps and their underlying studies are also the foundation of numerous other programs at TRCA, including:

- Flood Forecasting and Warning Program,
- Flood Vulnerable Area and Roads Database,
- Flood Risk Assessment and Ranking, and
- Flood Risk Reduction and Flood Protection Remedial Studies including environmental assessments and feasibility studies.

Furthermore, TRCA's flood plain mapping program and associated studies provide key information relating to:

- Special Policy Areas,
- Land use planning updates including Official Plans, Block Plans, Zoning Bylaw, and
- Flood Protection and Remediation projects with significant public investment, including projects initiated and driven by municipal partners.

The information is further utilized for emergency and incident management planning, and infrastructure planning and implementation purposes.

With an ever-expanding utility, constant land use changes, advancements in computing capabilities, and the development of sophisticated modelling software including Two-Dimensional (2D) Modelling, best practice within TRCA is to conduct flood plain mapping updates on a 10-year cycle to ensure TRCA's mapping remains current and state-of-the-art. As such, in 2016 TRCA initiated the most recent comprehensive flood plain mapping update which was further accelerated through the availability of NDMP funding.

RATIONALE

Flood plain mapping updates are multi-phased projects that require several studies to be completed before maps can be generated. The first phase consists of the development of a detailed hydrology model to obtain peak flow estimates at any point within the watershed. The second phase consists of the development of a detailed hydraulic model of the watershed to obtain water surface elevations throughout valley and stream corridors. The final phase is the development of topographic maps which identify surface elevations and geospatial data like roads, houses, bridges, and other base-map elements.

Hydrology

Watershed Hydrology is the study of how water moves through the water-cycle. For flood plain mapping purposes, it is the study of how TRCA's watersheds with current and planned land-use changes would respond to rainfall events like Hurricane Hazel as well as hypothetical storms. As noted above, hydrology studies are the first process that needs to be completed to undertake flood plain mapping updates. To help inform hydrology model updates, TRCA continually collects monitoring data (stream flow and precipitation), as well as information on land-use, topography, land cover, and soil.

There have been a number of advancements in modelling software, computing capabilities, and input data like Light Detection and Ranging (LiDAR) which allow TRCA staff to obtain a very good physical representation of the watershed. These advancements have led to the development of higher resolution models capable of predicting flows at a smaller scale and allowing direct input for each catchment into hydraulic models. Previously, manual calculations were be required to interpolate flows between a number of points within the watershed. The newer method ensures a more realistic representation of hydrology inputs into hydraulic models, and less user interpretation.

A list of recent hydrology model updates as well as their funding source is available for view in Table 1 below:

Table 1: Summary of Hydrology Updates

Watershed	Date	NDMP Project
Humber River	2015 (Addendum 2018)	No

Rouge River	2019	No
Don River	2019	No
Highland Creek	2020	Yes
Mimico Creek	2020	Yes
Petticoat Creek	2020	Yes

Several watershed hydrology updates, (Humber River, Rouge River, Don River) have previously been presented to the Board of Directors for approval, reflecting the provincial, municipal, and development-related interests in those watersheds.

In addition to Board approval, hydrology updates for the Humber, Don, and Rouge River watersheds included a detailed third party Peer review process to further confirm and validate the model update process and results to ensure consistency with acceptable engineering practice, and further meet MNRF requirements. For all hydrology model updates, TRCA staff complete detailed reviews of consultant submissions which exceed the typical reviews undertaken through the third-party peer review process. Once the model and results have been approved by staff, they can be used for flood plain mapping studies, and if required, further hydrologic assessments can be conducted to define watershed-specific stormwater management quantity control requirements.

Hydraulics

Open channel hydraulics is the study of how water moves through an open flow conduit like a river channel or valley corridor. A hydraulic model is a representation of the physical characteristics of the valley and stream corridor, including the channel and valley shape, slope, land-use (and the corresponding resistance to flowing water), and water crossings (bridges and culverts). Hydraulic modelling defines the extent of the flood plain, based on these characteristics and the flow inputs for a given storm based on the hydrology model. Hydraulic models provide detailed outputs of various model results, like water surface elevations and velocity which are important for defining flood extents and flood risk.

TRCA uses two different modelling approaches to define floodlines within our watersheds. The majority of TRCA's jurisdiction uses the one-dimensional (1D) modelling approach, while in select areas, where complex hydraulic conditions exist, TRCA uses the two-dimensional (2D) modelling approach.

As noted above, the 1D modelling approach is appropriate for the majority of TRCA's jurisdiction as flood waters are contained within defined valley corridors and flows generally move downstream in one direction. TRCA's modelling software for 1D modelling is the HEC-RAS model developed by the US Army Corps of Engineers Hydrologic Engineering Centre. The HEC-RAS model is well understood, is fully supported by a large international user community, and is the standard 1-D hydraulic modelling platform in Ontario. It is important to note that the development of 1D hydraulic models can be labour-intensive, requiring significant data input to represent water crossings and code topographical information into valley cross-sections. TRCA currently leverages several custom modelling platforms and GIS applications to expedite the creation and review of hydraulic models. In anticipation of the high volume of flood plain mapping updates due to NDMP funding, TRCA purchased several GeoHEC-RAS licences in 2017. GeoHEC-RAS is a software program that integrates GIS utilities on a HEC-RAS model base, and is developed by Civil Geo, a developer specializing in hydraulic modelling tools. GeoHEC-RAS allows TRCA to perform "on the fly" modelling edits which are translated immediately into floodline adjustments, greatly improving the ability to turn over model reviews

and edits in a timely manner.

2D modelling is used in specific areas where flood flows are not contained in a valley corridor, areas with wide, shallow flood conditions, areas where multiple major channel confluences exist, and in areas where complex hydraulic conditions exist. Given the scale and urban nature of TRCA's watersheds, TRCA has a number of locations which require the use of 2D models to define the flood plain extent. TRCA's first 2D modelling study was initiated in 2013, and to date TRCA has used 2D modelling for over 13 flood plain mapping and flood infrastructure studies. Although the model computations in 2D modelling are more complex, requiring significant computational resources and longer run-times, 2D model set-up is much less labor intensive than 1D models. This reflects the gridded nature of 2D models, which require very similar input parameters to the 1D modelling approach. 2D modelling platforms, however, can leverage GIS mapping products for a direct translation of model parameters like topography, land-use, and land cover from GIS products into the model grid, or mesh,

TRCA's standard 2D modelling platform is MIKE Flood which was developed by the Danish Hydraulic Institute (DHI). MIKE Flood is used internationally and can integrate 1D open channel hydraulics and 2D overland flow hydraulics allowing the transition of flow between the two modelling environments. Through investments in computing resources, licence purchases of MIKE Flood, the recruitment of experienced 2D modellers, and staff training, TRCA has built substantial in-house expertise and capacity in this field. Although historically, 2D modelling studies have been undertaken by external engineering consulting firms, TRCA now has the resources and ability to complete 2D modelling assessments in-house. Furthermore, TRCA staff provide valuable advice and input into 2D hydraulic modelling assessments being undertaken by other Conservation Authorities, our municipal partners, and the consulting industry, and are leaders in 2D modelling in Ontario.

While many flood plain mapping studies, and the associated models, have been developed by consulting engineering firms, all hydraulic models are subject to rigorous quality assurance/quality control (QA/QC) processes prior to approval. The QA/QC process ensures that TRCA's models are developed using industry standards that reflect the technical guidance provided by MNRF, which incorporates several conservative assumptions. The process ensures that models leverage the best available data sources and appropriate input parameters to ensure model results are accurate and representative of watershed conditions. Unlike hydrology models, TRCA does not undertake third-party peer reviews for hydraulic modelling updates, this reflects the detailed nature of TRCA's QA/QC process and unparalleled experience and expertise that currently exist at TRCA.

Base Mapping

Historically, base mapping represented the highest cost component of the flood plain mapping update process. TRCA was required to purchase base mapping, which met MNRF technical requirements, from a limited number of mapping vendors. In recent years, TRCA GIS staff have developed and implemented an in-house base map development program for the purpose of establishing a consistent mapping set for flood plain mapping updates. This in-house process ensures a consistent approach is used when developing mapping products, and leverages TRCA's LiDAR data, and digital planimetric data developed by municipal partners. The new base mapping process leverages staff resources, saves time, and budget.

To complete flood plain mapping, the results from TRCA's hydraulic models are transposed onto base maps. Prior to finalization, GIS and Engineering Service staff complete a detailed review of the resulting floodline to ensure the mapping and modelling products are consistent in

terms of topographic representation (elevation contours) and flood plain elevation. Once the mapping QA/QC process has been completed, the resulting flood plain map is deemed complete and can be signed and stamped by a Professional Engineer. Once signed and stamped, the map can be used in the land-use planning and regulation review processes and can be circulated to municipal partners and the general public. A public-facing flood plain map viewer, together with a set of Frequently Asked Questions, has been available on the TRCA website for a number of years.

With the new base mapping process, mapping deliverables differ in format from historical flood plain mapping updates. Previously project submissions required hard copy floodline maps at a scale of 1:2000, on 24"x36" map sheets. GIS staff would orient map sheets to maximize coverage and establish map cut lines based on logical transition points like roads and water crossings. Flood plain map sheets would be circulated to interested parties using this format regardless of the area of interest.

Project deliverables now consist of digital floodlines overlaid on digital base mapping of the entire watershed. This new process allows for the development of custom mapping products for interested parties with less staff time involved in developing and orienting set-size map sheets. Mapping is frequently requested by municipal partners, the development industry and associated professional consulting firms, as well as the general public. Custom maps can be prepared easily based on the needs of the user; consulting engineers well-versed in flood plain mapping can request the full suite of mapping information, whereas the general public can be provided simplified maps with the floodline overlaid on an aerial photo base. In all instances, the full mapping product can be made available via the existing data request channels for any interested party.

A list of recent hydraulic model and flood plain mapping updates as well as their funding source is available for view in **Attachment 1**. A map view of the year-by-year comprehensive flood plain mapping updates is available in **Attachment 2**. Note that there are specific 2D areas of study within these watersheds that may have different dates of completion.

Outcomes and Next Steps

Updating flood plain mapping does not alter the flood risk in a given location; it is a technical process that provides an updated *understanding* of the risk at that location based on the best available information. Although comprehensive flood plain mapping updates have been completed for the majority of TRCA watersheds, a number of emerging issues and other program updates will need to be addressed and completed. These consist of the following:

- TRCA's approaches to managing natural hazards with respect to planning and development are outlined in the Living City Policies. While flood plain mapping information is regularly updated, the development and infrastructure planning process advances through a complex hierarchy. Therefore, it is possible for updates to flood plain mapping or hydrology models to occur at various stages of the planning hierarchy. As a result, there may be instances where the review and support of a proposed development by TRCA has previously occurred and the application is proceeding to the next planning stage on the basis of information that changes mid-process. The Conservation Authorities Act is the jurisdictional authority in the permitting process and does not provide for the grandfathering of historical planning decisions. For transitional files (as recognized by TRCA staff), where it is technically feasible and appropriate, innovative design approaches may be considered to address site constraints and accommodate the development while meeting current regulatory requirements. TRCA is committed to utilizing the best available information to achieve the

policy objectives noted in Section 8.3 of the Living City Policies, including minimizing the risk to people and property due to natural hazards.

The best available information may include updated hydrology model outputs, hydraulic model updates that have passed the point of quality assurance and quality control checks, and updated flood plain mapping that may still be in draft form. It is important to recognize that a solution may not always be technically feasible, and that the above only applies to transitional files that have recent previous support from TRCA staff for the same application. Engineering Services, Development Planning and Permitting, and Planning Policy and Regulation staff are developing an internal guidance document for staff to provide a consistent approach to areas where new floodlines may impact ongoing development and infrastructure applications that have previous TRCA support.

- As the flood plain is the flooding hazard limit, resultant changes to TRCA's Regulation Limit will be undertaken by Engineering Services, Planning Policy and Regulation, and Information Technology and Records Management staff. The results of the Regulation Limit update will be communicated to the Board of Directors yearly by the Planning Policy and Regulation team, as per the current practice.

- Engineering Services staff will initiate a process to update TRCA's Flood Vulnerable Areas and Roads (FVA) database with the modelling results from the most recent flood plain mapping updates. The FVA update will also result in an update to the Flood Risk Assessment and Ranking of flood vulnerable clusters (neighbourhoods).

- Several of the recent flood plain mapping updates have defined areas which warrant further analysis and study, including a number of significant spills, and areas where complex hydraulics exist. Flood Risk Management and Water Resources Engineering staff within Engineering Services will develop a process to rank these areas in terms of risk and development pressures to undertake further assessments, including 2D modelling to quantify flood characteristics, spill extents, and provide a means to "close" floodlines,

- Engineering Services staff will continue to expand our mapping coverage with focus on white belt lands in the Regions of Peel, York, and Durham.

- Given the significant investment for flood plain mapping updates over the past number of years, Engineering Services will actively maintain TRCA's current flood plain map set, including incorporating flood studies and assessments developed as part of development applications and municipal infrastructure works.

- Engineering Services, together with Planning Policy and Regulation, will communicate with municipal partners on the results of TRCA's current flood plain mapping updates, as well as any future hydrology or flood plain mapping studies. Staff will provide an opportunity for stakeholders and interested members of the public to participate in virtual meetings to view, in greater detail, the updated mapping. Note that an up-to-date flood plain mapping viewer is available on the TRCA website.

- TRCA has been selected, together with other Conservation Authority representatives, to participate in the Flood Mapping Technical Team that is being assembled as part of the Ontario Flooding Strategy. This will provide an opportunity to share TRCA's experience and exchange knowledge gained through the significant flood plain mapping efforts undertaken

as part of the National Disaster Mitigation Program This will provide TRCA an opportunity to provide input towards the critical task of updating provincial guidelines and standards to reflect current modelling technology and the urban/urbanizing context.

As noted above there are a number or processes, procedures, and on-going initiatives related to TRCA's flood plain mapping program which will require input from across the organization. Furthermore, staff have recently been informed that a new intake of the NDMP funding program is likely for projects to be completed in the 2021/2022 federal fiscal year. TRCA staff will continue to pursue NDMP funding to complete flood plain mapping updates for remaining watersheds (Frenchman's Bay and Petticoat Creek), expand flood plain mapping coverage, and undertake further assessments for spills and areas with complex hydraulic conditions.

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 4 – Create complete communities that integrate nature and the built environment
Strategy 7 – Build partnerships and new business models

FINANCIAL DETAILS
Financial contributions for TRCA's flood plain mapping update program have been provided by a number of funding sources including the Regions of Peel, York, and Durham, the City of Toronto and the NDMP through accounts 127-90 Floodplain Mapping Program, 107-02 Flood Protection and Remedial Studies, and 129-19 Flood Remedial Works. Matching funds were provided for many of the studies through the federal National Disaster Mitigation Program.

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Date: September 25, 2020
Attachments: 2

Attachment 1: Summary of TRCA's Hydraulic Modelling and Floodplain Mapping Updates 2016 - 2020
Attachment 2: Overview Map of TRCA's Hydraulic Modelling and Floodplain Mapping Updates 2016 - 2020

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Attachment 1: Summary of TRCA's Hydraulic Modelling and Floodplain Mapping Studies 2016 – 2020

Project Title	Date	NDMP Project	Hydraulic Modelling Approach	Notes:
Etobicoke Creek Floodplain Mapping Update	2016	No	1D	
Yonge St. and Elgin Mills Road Floodplain Mapping Update	2016	No	2D	Significant cost savings by leveraging modelling work completed by the City of Richmond Hill for Yonge and Elgin Mills Flood Remediation Environmental Assessment
Downtown Brampton Floodplain Mapping Update	2017	No	1D	
Lower Humber River 2D Modelling Study	2015 / 2017	No	2D	**Revised in 2017**
Pickering and Ajax SPA 2D Modelling Study	2018	Yes	2D	
Black Creek at Rockcliffe SPA 2D Modelling Study	2018	Yes	2D	
Humber River in Peel Region Floodplain Mapping Update	2018	No	1D and 2D	2D MIKE Flood model was developed for Caledon East.
Humber River in the City of Toronto Floodplain Mapping Update	2018	Yes	1D and 2D	2D MIKE Flood model was developed for Albion Creek.
Spring Creek 2D Model Extension and Floodplain Mapping Update	2019	Yes	2D	
Carruthers Creek Floodplain Mapping Update	2019	Yes	1D and 2D	First comprehensive floodplain mapping update completed in-house. 2D MIKE Flood model developed for the Lower Carruthers Creek through the Pickering Beach Community.
Humber River in York Floodplain Mapping Update	2019	Yes	1D	
Unionville SPA 2D Modelling and Floodplain Mapping Update	2019	Yes	2D	Communicated to the Board at meeting #5/19, on Friday, May 24, 2019
Highland Creek Floodplain Map	2020	Yes	1D	
Don River Floodplain Mapping Update – Phase 1	2020	Yes	1D	
Rouge River Floodplain Mapping Update – Phase 1	2020	Yes	1D	
Don River Floodplain Mapping Update – Phase 2	2020	Yes	1D	
Rouge River Floodplain Mapping Update – Phase 2	2020	Yes	1D	
Duffins Creek Floodplain Mapping Update	2020	Yes	1D	

Item Clerk to insert #

Attachment 2: Overview Map of TRCA's Hydraulic Modelling and Floodplain Mapping Updates 2016 - 2020

(Note: detailed studies such as 2-D modelling updates within watershed-wide updates may have different years of completion)