Item 9.1

Section III – Items for the Information of the Board

TO: Chair and Members of the Board of Directors
Friday, April 28, 2023 Meeting

FROM: Sameer Dhalla, Director, Development and Engineering Services

RE: **2023 FLOOD INFRASTRUCTURE STATE OF REPAIR REPORT**

KEY ISSUE

Report on the current state of repair of Toronto and Region Conservation Authority (TRCA) flood control infrastructure, including major deficiencies, and overview of dam safety regulatory guidelines, risk management approaches, and repair projects.

RECOMMENDATION:

IT IS RECOMMENDED THAT the 2023 TRCA Flood Infrastructure State of Repair Report, be received.

BACKGROUND

At Authority Meeting #4/13, held on May 24, 2013, Resolution #A87/13 was approved as follows:

> THAT the Toronto and Region Conservation Authority (TRCA) Flood Management Service Flood Infrastructure State of Repair Report be updated and reported to the Authority bi-annually.

The last TRCA Flood Infrastructure State of Repair Report was presented at the Authority Meeting #8/20.

The purpose of the report is to document the current state of repair of TRCA-owned flood infrastructure and to outline the major capital improvement projects that have been implemented or that are required in the future. Information on the process of identifying projects, funding sources, and the regulatory framework for dam safety in Ontario is also included in this report.

TRCA's objective to mitigate known flood risks, including the operation, maintenance, and surveillance of flood infrastructure is aligned with the Strategic Plan 2023-2034 under Pillar 1: Environmental Protection and Hazard Management. Section 1.1 of the Strategic Plan specifies that TRCA provides provincially mandated services for flood monitoring and risk management including the operation of flood mitigation infrastructure. Section 4.2 of Pillar 4: Service Excellence requires that TRCA complete asset management plans and state of repair assessments. Additionally, Conservation Authorities are mandated, under Section 21 of the Conservation Authorities Act, to ensure conservation, restoration, and responsible management of Ontario's water resources. Section 21 empowers Conservation Authorities to:

- erect works and structures and create reservoirs by the construction of dams or otherwise;

- control the flow of surface waters in order to prevent floods or pollution or to reduce the adverse effect thereof.

As part of this mandate, TRCA develops and maintains programs to prevent loss of life and property damage from flooding hazards. This includes structural flood mitigation options such as dams, dikes, and flood control channels which are collectively referred to as flood infrastructure. TRCA has constructed flood infrastructure to reduce risk in flood vulnerable communities. The majority of TRCA's flood infrastructure was built between the late 1950's and the early 1980's, primarily as part of the response to the Hurricane Hazel flood of 1954. TRCA has also acquired several historic dams through various land acquisition programs. A general location map of all TRCA flood infrastructure is provided in **Attachment 1**. For reference, **Attachment 4** contains photos of various structures and related projects.

Dams

TRCA's dam inventory consists of 12 dams, of which 5 were specifically built to provide flood protection. The other dams are historical industrial or recreational structures that were acquired through various TRCA land acquisition programs. TRCA dams range in age between 45-85 years old and most require major capital improvements to meet current dam safety guidelines. A list of TRCA-owned dams is included in **Attachment 2**.

Dams carry inherent risk because they are susceptible to failure through overtopping, structural failure, and uncontrolled seepage. Internationally, there have been recent dam safety incidents that have resulted in loss of life, mass evacuation, population displacement, environmental degradation, and extensive property damage. The consequences of dam failures underscore the importance of having a robust dam maintenance program at TRCA.

Dams are technically complex and require extensive and constant monitoring, maintenance, and repair.

Flood Control Channels

Flood control channels are designed to increase the amount of flow that can be conveyed through a length of watercourse compared to a natural channel. Flood control channels are created by replacing the natural watercourse with an engineered channel to protect adjacent areas from flooding. Flood conveyance is increased by lining the channel with concrete or stone to reduce resistance to the flow of water. Flood control channels often straighten the watercourse to increase flow conveyance. Flood control channels are extremely damaging to the natural processes of a river and very little can be done to retrofit flood control channels in existing urban environments to restore ecological functions and mitigate the environmental loss. Because they do not retain water, flood control channels have less risk than other flood control structures because they do not impound water. A failure of a channel does not cause an uncontrolled release of water that can create catastrophic flooding, unlike a dam or dike and they are therefore often a safer option for flood control.

TRCA's flood control channels were built in communities with historic flood risk. These communities were built prior to the existence of TRCA's regulations for limiting development in the floodplain and building flood control channels adjacent to these communities was determined to be the most effective way of reducing flood risk. TRCA owns 9 flood control channels totaling approximately 11.5km. Of this, 8.5km is of concrete, trapezoidal design

and the remaining channel types are a mixture of rip rap and gabion basket design. A list of TRCA's flood control channels is provided in **Attachment 2**.

Flood control channels require regular maintenance to ensure flood conveyance is maintained. Engineered channels disrupt the normal flow and sediment transport of a natural river. Sediment tends to accumulate rapidly, and vegetation will start to root, reducing the capacity of the channel. Blockages can also occur requiring regular monitoring and cleanouts to reduce flood hazards. TRCA undertakes regular inspections and sediment/vegetation removal in all channels to ensure capacity of the channel is maximized to the greatest extent possible.

Flood Control Dikes

TRCA owns 6 dikes totaling approximately 3.6km. Dikes, also known as berms or levees, are defined as an embankment built to control or hold back water. Dikes are primarily earthen embankment structures, although one structure owned by TRCA was constructed as a masonry wall**.** Dikes are typically built parallel to a river to prevent water from entering adjacent, developed areas. Like dams, dikes hold back water during periods of high flows, however, dikes are not considered dams under definitions provided by various dam safety and regulatory agencies. The Canadian Dam Association (CDA), is working on guidelines for designing, constructing, and assessing dikes for safety. It is expected that these guidelines will take several years to develop, and once finalized, will be used in determining the standards for operation and maintenance of TRCA's dikes. TRCA will be assisting the CDA in developing these new guidelines. For current standards for dike safety, TRCA and engineering consultants take relevant parts of dam safety guidelines and adapt them for investigating the condition of a dike.

Dikes, like dams, carry more risk than channels because a dike failure during a flood would create a situation where there would be an uncontrolled release of water into the area protected by the dike. A list of TRCA's dikes is provided in **Attachment 2**.

Flood Protection Landforms (FPL), while technically not classified as dikes, are a type of flood infrastructure that performs the same function. FPLs are very large dike structures that are designed in such a way to prevent failure so as to ensure permanent flood protection. The construction of FPLs requires them to be high enough and wide enough that they cannot breach and release water like traditional dikes. All potential failure modes are considered and eliminated through "over-engineering" the structure. FPLs can withstand overtopping, seepage, settlement, erosion, and other stressors to ensure that they can survive any flood. FPLs, because they can't fail, are considered passive flood control, and are constructed in flood plains to allow development to occur by eliminating flood risk. FPLs require extensive engineering, specialized construction, complex approvals, and large areas of land and therefore are only used in very specific circumstances. TRCA owns one FPL on the west side of the Lower Don River. This FPL includes a clay core and other significant design features that protect a large area of downtown Toronto. The performance of this FPL was a pre-requisite for redevelopment of the West Don Lands and has served as a catalyst for redevelopment through removal of a historic Special Policy Area designation that previously extended from Bay Street in the west to south of Queen Street at the Don River in the east. TRCA is currently working with partners including the City of Toronto and Waterfront Toronto on design of the Eastern Broadview FPL.

TRCA's portfolio of dams, dikes, and channels are aging, and many have experienced deterioration that could affect their performance, safety, and stability. Engineering specifications have also evolved to become more conservative, which renders older structures unable to meet new regulations, guidelines, and best practices. The regulatory framework for managing dams is constantly shifting as knowledge of hazards and risks advances. TRCA, through studies and inspections, continues to track and document deficiencies at dams, dikes, and channels to prioritize capital works. Deficiencies associated with each structure are listed in **Attachment 2**.

Over the last 15 years TRCA has made significant investments to remediate its inventory of flood protection structures to meet its objectives of protecting the public from flood impacts. TRCA is committed to continued improvements to the state of repair of all dams, and channel and dike systems that it manages.

RATIONALE

Flood infrastructure is designed to protect life and property, but also carries risk. The failure of structures designed to store and divert flood water can cause an uncontrolled release of water into developed areas. As an owner of dams, channels, and dikes, TRCA must strive to ensure these structures are managed safely.
The following sections of this report outline:

a) Dam safety in Ontario and the framework in which TRCA operates, maintains, and inspects flood infrastructure;
b) Components of TRCA flood infrastructure safety programs;
c) Current state of repair summary and associated risk of TRCA flood infrastructure;
d) Completed and proposed major studies and repairs from 2019 to 2025; and
e) Funding details and grant opportunities.

Dam Safety in Ontario

Dam safety in Ontario is regulated by the Ministry of Natural Resources and Forestry (MNRF) under the Lakes and Rivers Improvement Act (LRIA). They are responsible for developing the criteria that dams must meet and regulating dam owners in the safe operation and maintenance of dams. The Canadian Dam Association (CDA) is an advisory body comprised of voluntary dam safety experts supported by dam owners in Canada, including TRCA. The CDA provides technical and management guidance for dam owners using internationally recognized best practices. TRCA uses a combination of both MNRF and CDA guidelines for managing structures. This is because there are cases where one set of guidelines does not cover specific topics. For example, LRIA guidelines do not address emergency management of dams and therefore TRCA uses the CDA Emergency Management for Dam Safety Technical Bulletin.

<u>Lakes and Rivers Improvement Act</u>

In 2011, the Ontario Ministry of Natural Resources and Forestry (MNRF) introduced the Lakes and Rivers Improvement Act (LRIA) Administrative Guide, Technical Bulletins and Best Management Practices Guide. These documents are based on criteria developed by MNRF and the Canadian Dam Association (CDA) with input from dam owners, engineers, and regulators. They provide guidelines for the safe design, construction, management, operation, and repair of dams in Ontario. It is a resource for engineers, operators, and owners to use when assessing the safety of a dam. The LRIA Guidelines are not legislated

but define best management practices and therefore the minimum standard of safety for dam owners in Ontario.

A primary component of the LRIA is the Dam Safety Review (DSR). The DSR is an in-depth engineering study of a dam. Components of a DSR include geotechnical analysis of stability, a public safety review, hydro-technical analysis, structural inspection, and other investigations. Based on the results of the DSR, the dam receives a Hazard Potential Classification (HPC). The HPC determines the risk to the public if a dam were to fail. Dams with higher risks are required to meet more stringent and conservative engineering standards. For example, a dam failure that is estimated to cause a loss of life greater than 10 persons would have an HPC of Very High. Dams with an HPC of Very High would have to meet the strictest guidelines for dam safety including safely passing the largest theoretical flood that can occur in southern Ontario (which, for reference, is larger than Hurricane Hazel). Safely passing a flood means that the resulting flows can pass through the dam and reservoir without overtopping and creating a failure of the structure. **Attachment 2** includes HPC's for each dam in TRCA's inventory. The criteria from the LRIA Classification and Inflow Design Flood Technical Bulletin for assessing HPC is also included for reference in **Attachment 2**, Table 4.

Canadian Dam Association Dam Safety Guidelines

The CDA is a volunteer body of dam safety experts who create dam safety guidance documents using the best industry standards developed by various international organizations. CDA also develops training and workshop programs that offer training for dam professionals. Particularly important recommendations from CDA include the development of emergency management guidelines. These provide a framework for responding to dam failures. TRCA assisted in the development of the emergency management guidelines and was an early adopter of CDA's recommendations for developing emergency management protocols. All TRCA high risk dams have emergency response plans in place.

TRCA Flood Infrastructure Management Program - Dams

Dam Safety Management

TRCA's four largest dams are in urban areas. As such, a failure of one of these dams would have a significant impact on downstream communities. For example, the 2011 Dam Safety Review of G. Ross Lord Dam determined that a failure of the dam could place up to 3,000 persons at risk and cause up to approximately $1.3 billion in property damage. Proper management and maintenance of these dams is critical for public safety.

TRCA has adopted LRIA and CDA guidelines into its dam safety management program and is in the process of upgrading each structure to meet the criteria required, where possible.

Inspection Program

Each dam in TRCA's inventory is inspected monthly with a more thorough inspection annually. TRCA's two largest dams (Claireville Dam and G. Ross Lord Dam) also undergo daily inspections for early identification of issues that could indicate potential failure modes that could be developing. A list of deficiencies for each structure is provided in Table 1 in **Attachment 3**. The total number of inspections on TRCA dams is approximately 550 each year. Inspection types consist of the following:

- Daily inspections are visual inspections to note the condition of the earthen embankment, control structures and site security.
- Monthly inspections are more detailed. Emergency generators are run, gate motors are tested, back-up systems tested, communications equipment checked, dam instrumentation is calibrated, and embankments are visually inspected.
- Annual inspections are very detailed assessments of each dam. Each component is thoroughly checked for correct operation:
    - earthen embankments are thoroughly inspected
    - gates are fully opened and closed
    - concrete spillways are inspected
    - gates are operated on emergency power
    - tunnels and shafts are entered and inspected
    - emergency generators serviced
    - gates and motors are lubricated and serviced
    - back-up gate operation systems tested

Operation, Maintenance and Surveillance Manuals

Each dam owned by TRCA has an Operation, Maintenance and Surveillance (OMS) manual. The OMS manual is a stand-alone document that describes all the activities necessary to manage the dam safety. Sections of an OMS include:

- roles and responsibilities with contact information
- how to operate the dam gates
- operation of emergency generators
- preventative maintenance procedures
- communications
- dam storage and discharge data
- emergency procedures
- inspection criteria

Each OMS is reviewed and updated each year to ensure the document is current.

Emergency Preparedness and Response Plans

TRCA uses CDA's Emergency Management for Dam Safety Technical Bulletin for guidance on drafting emergency response plans specific to each structure. There are two types of emergency management plans for dams. Emergency Preparedness Plans (EPP) are developed for external responding agencies that are responsible for public safety. In the event of a dam emergency, the responding agency can use the EPP to coordinate resources using the EPP's inundation maps. Inundation maps depict the expected flooded areas should a dam fail and can help first responders coordinate evacuations and road closures, if required. Emergency Response Plans (ERP) are internal documents for TRCA use. Contact information for staff, roles and responsibilities, organizational flowcharts, equipment/aggregate supplier information, emergency dam repair documentation, and other critical information for managing dam emergencies are included in the ERP. TRCA maintains EPPs and ERPs for all high risk dams in its inventory.

Asset Management Plans

Asset Management Plans (AMP) are used internationally by organizations to assist in maintaining an acceptable state of repair for infrastructure. Key components of an AMP include:

1. Asset inventory of infrastructure. This includes type, location, construction date, cost, and expected life cycle.
2. Condition Assessment. Structure is inspected and given a ranking of condition, usually using a scale between Very Good to Very Poor.
3. Asset lifecycle cost analysis. Refers to the cost to maintain the structure over its expected life span. Includes maintenance, capital expenditures, and other costs.
4. Level of Service (LOS) where the quality, function, performance is evaluated to ensure the asset is meeting the needs of the users.
5. A financial planning roadmap to prioritize funding to ensure infrastructure is meeting LOS minimums.

Ontario Regulation 686/21, under the Conservation Authorities Act, came into effect January 1, 2022. Section 5(2)(2) of the regulation stipulates that any water control structure owned by a conservation authority must develop and implement an Asset Management Plan (AMP) by December 31, 2024. TRCA is already in the process of developing AMPs for all tangible assets:
At Authority Meeting #2/21, held on February 26, 2021, Resolution #A23/21 was approved as follows:

> THAT the staff report regarding the update on the development of TRCA's Asset Management Plans be received.

This report provides an update on the development of Asset Management Plans for all TRCA tangible assets including flood infrastructure. Since this report, TRCA has retained the services of a consultant to provide guidance on developing industry standard AMPs, and a software package to record, track, and report on assets. The software tool will be in place for Q1, 2023. TRCA will have AMPs in place for all flood infrastructure by 2024 that will be consistent with all TRCA assets. More work in 2023 is required to finalize the AMP so that it is in line with all TRCA asset reporting, and these results will be included in the next State of Repair report in 2024/2025.

Studies, Repairs and Preventive Maintenance

Due to the complexity of dam construction and associated risk, TRCA undertakes numerous engineering studies to investigate the condition of the structures. Dam Safety Reviews (DSR's) are the most common study, but other investigations may be required as well. It may be necessary to design a repair or to further investigate a deficiency. For example, in 2019, a DSR at Palgrave Dam found that the dam may be at risk of failure during an earthquake, warranting either further study on seismic risk, or alternatively a costly stabilization project. In 2022, a specialized study was initiated using the latest seismic risk investigations to confirm whether a costly repair was warranted. Preliminary results indicate that expensive repairs are most likely not warranted.

When inspections or studies find that repairs are required, TRCA retains qualified consultants and contractors to undertake the repair. Most common repairs include electrical

upgrades at dams, dredging of flood control channels, and minor concrete repairs. Major deficiencies require extensive design, complex approvals, and significant capital funds. TRCA is investigating opportunities to obtain adequate funding to undertake some of the major work required to make TRCA infrastructure fully compliant with current guidelines.

Preventative maintenance is a critical part of TRCA's management of dams. In 2019, TRCA assigned a full-time field crew to specifically undertake preventative maintenance activities on flood infrastructure. Preventative maintenance on dams is primarily geared toward removing vegetation from embankments. Removing vegetation on a regular basis prevents large trees from establishing root systems that can damage the embankment. Trees on dams can also lead to seepage issues and impair an inspector's ability to see the condition of the embankment. Preventative maintenance activities on dams can also include minor concrete repairs, debris management at dam intakes, and painting of gate components. By undertaking regular preventative maintenance, TRCA expects to reduce the future expense of large capital projects.

Public Safety Around Dams

Dams in Ontario are required to follow the Public Safety Around Dams (PSAD) Technical Bulletin from the LRIA. Statistically, it is far more likely to have serious injury or death around a dam due to falls or drownings than from a dam failure. The PSAD evaluates all the hazards around a dam and prescribes mitigation measures to ensure that all areas of the dam are safe. Mitigation primarily includes barriers (fencing, guardrails, and safety booms) and warning signage. PSAD documents for TRCA dams are reviewed annually to ensure all hazards are properly mitigated.

Dam Decommissioning

There are many technical difficulties in bringing older dams into compliance with modern design guidelines. Older dams were constructed using the engineering principles of the period in which they were built and cannot meet newer requirements unless substantial modifications are made. Some historic dams such as Palgrave Dam or Osler Dam, were built without any proper engineering or construction techniques and will never be able to meet LRIA guidelines without unreasonable capital expenditures. In these cases, options are limited to decommissioning the dam or increased risk management and tolerance. TRCA has decommissioned several dams in the past. Most recently, Albion Hills Dam was decommissioned in 2017 because the structure was in poor condition and unrepairable. There are several other dams in TRCA's inventory that will need to be decommissioned or replaced because their poor condition puts them at risk of failing. These include:

- Secord Dam
- Osler Dam
- Glen Haffy Extension Upper Dam
- Glen Haffy Extension Lower Dam

Studies are underway on the Glen Haffy Dams to investigate decommissioning options. Removing these unrepairable structures reduces TRCA liability and long-term costs. Even small dam failures can cause large amounts of property and environmental damage. Additionally, removing dams restores the river's natural functions and usually improves habitat and water quality.

Major Dam Safety Projects 2016-2022

There were numerous projects undertaken at TRCA dams since 2016. Projects are a combination of repairs and studies and are outlined below along with proposed dam safety projects through 2025. Completed and proposed projects from 2016 to 2025 are listed in Table 1.

Table 1 Major Dam Safety Projects 2016-2025

Structure	**Year**	**Project**	**Project Cost**
G. Ross Lord Dam	2024	Dam Safety Review • New Dam Safety Review required.	$150,000
Palgrave Dam	2023/2024	Stop Log Gantry Installation • Design and installation of new stop logs and hoisting system.	$75,000
Claireville Dam	2023	Gate Decommissioning • Implementation of gate repair.	$50,000
Claireville Dam	2023	Wing Wall Repair • Implementation of repair to wing wall.	$150,000
G. Ross Lord Dam	2023	Seepage Study Phase 2 • Continued investigation into dam's drainage system.	$80,000
Palgrave Dam	2022	Deficiency Repair Design Study • Design of repair to address deficiencies.	$148,000
Claireville Dam	2022	Gate Decommissioning Study • Study to decommission unused gate.	$40,000
Glen Haffy Dams Safety Review	2022	Dam Safety Review and Feasibility Study • Investigation of four dams within the Glen Haffy Conservation Area. • Decommissioning feasibility study.	$160,000
Claireville Dam	2022	Wing Wall Repair Design Study • Study to investigate wing wall settlement.	$85,000
G. Ross Lord Dam	2021	Emergency Spillway Seepage Study Phase 1 • Investigation into possible seepage risk	$225,000
Claireville Dam	2021	Gate Motor Housing Repair • Repair weather enclosures for gate hoisting equipment.	$33,000
Stouffville Dam	2021	Concrete Repair	$48,000

		• Repair cracked and spalling concrete in spillway.	
Claireville Dam	2020	Control Building Roof Repair • Replace roof on control building.	$30,000
Claireville Dam	2020	HVAC Repair • Decommission boiler and install electric heaters throughout control building.	$35,000
Stouffville Dam	2020	Concrete Repair and Emergency Spillway Repair Design Study • Design for concrete and emergency spillway repairs.	$90,000
G. Ross Lord Dam	2019	Hydrogeological Study • Study to examine the dam's drainage and pressure relief systems.	$85,000
Stouffville Dam	2018	Liquefaction Study • Study to determine earthquake risk to dam.	$63,000
Palgrave Dam	2018	Dam Safety Review • Engineering review of the dam.	$59,000
Milne Dam	2018	Deficiency Study • Investigate overtopping mitigation options. • Investigate structural sliding deficiency. • Confirm uplift resistance of spillway.	$84,000
Black Creek Dam	2018	Dam Safety Review • Engineering review of the dam.	$61,000
Black Creek Dam	2018	Reservoir Dredging • Remove sediment and debris from dam spillway intake and restore capacity of reservoir.	$1,760,000
Albion Hills Dam Decommissioning	2017-2018	Dam Decommissioning • Remove existing dam and construct bridge over restored creek.	$1,820,000

TRCA's Flood Infrastructure Management Program – Flood Control Channels and Dikes

Annual Inspections

As part of TRCA's Flood Infrastructure Management Program, channels and dikes are inspected annually. TRCA staff walk the entire length of each structure every year. Flood control channel inspections ensure that the channels are free from sediment and large

vegetation. Channel linings are inspected to ensure that they are not eroding. Concrete is checked to ensure that structures are not at risk of failing during large events. Dikes' earthen embankments are inspected to make sure the structures are not eroding, settling, or failing. Culverts and flap gates are checked to make sure that flood water cannot surcharge to the dry side of the dikes. Information obtained during the inspection is used to direct preventative maintenance activities and, in the case of more serious deficiencies, design repairs for capital works projects. Dikes and channels are also inspected after flood events to confirm that they were not damaged. A list of deficiencies for dikes and channels is provided in Table 2 and 3 in **Attachment 3.**

Maintenance

TRCA's flood control channels and dikes require maintenance activities to ensure that the structures are functioning correctly. Channels require dredging of sediment and removal of vegetation to ensure the capacity is maximized for flood events. Dikes should remain free of trees and large shrubs to allow inspections of the earthen embankments. Large trees can also topple during large storms causing root systems to damage large sections of the dike, possibly leading to failure. In the past, TRCA's flood control channels and dikes have received sporadic maintenance which has led to costly, large-scale sediment and vegetation removal projects. In 2019, TRCA dedicated a full-time maintenance crew to conduct small-scale maintenance on the channels and dikes. By undertaking annual maintenance on these structures, the need for expensive large-scale sediment and vegetation removal projects is greatly reduced.

Major Dike and Flood Control Projects 2016-2025

There were numerous projects undertaken at TRCA dikes and flood control channels since 2016. Projects are a combination of repairs and studies and are outlined below. Completed and proposed projects from 2016 to 2025 are listed in Table 1.

The following table outlines major channel and dike projects undertaken since 2016 (Table 2).

Table 2 Channel and Dike Projects 2016-2022

Structure	Year	Project	Project Cost
Stouffville Channel	2023	Proposed Feasibility Study • Study to investigate the feasibility of replacing existing gabion basket lining with a natural lining.	$50,000
Mimico Malton Channel	2023	Proposed Vegetation Removal • Preventative maintenance to remove vegetation.	$40,000
Etobicoke Dike	2023	Proposed Embankment Repair • Minor repair to eroded area of dike.	$20,000
Sheppard Channel	2023	Proposed Vegetation Removal • Preventative maintenance to remove vegetation.	$15,000
Stouffville Channel	2022	Vegetation Removal • Preventative maintenance to remove vegetation.	$14,000

Etobicoke Dike	2022	Dike Stability Assessment • Study to ensure dike meets stability requirements.	$25,000
Bolton Dike	2021	Bolton Dike Major Maintenance • Repairs to dike, including raising dike and installing new erosion protection.	$1,820,000
Yonge York Mills Channel	2020	Concrete Channel Repair • Concrete panel repair and underpinning.	$65,000
Bolton Dike	2019	Bolton Dike Ice Jam Study • Engineering assessment of the 2019 Bolton ice jam.	$55,000
Bolton Dike	2019	Bolton Dike Major Maintenance Design Project • Final Design drawings for Bolton Berm upgrades including erosion protection and raising of crest.	$160,000
Scarlett Channel	2019	Scarlett Channel Erosion Project • Repair erosion damage at outfall to Humber River.	$200,000
Bolton Dike	2018-2019	Bolton Dike Drainage Upgrades • Flap gate installation and maintenance	$20,000
Pickering Dike/Ajax Dike	2018-2020	Pickering/Ajax Dike Rehabilitation • Conservation Class Environmental Assessment	$450,000
Pickering Dike/Ajax Dike	2016	Pickering/Ajax 2D Modeling and Dike Assessment Project • Flood assessment and structural investigation of dike.	$75,000
Mimico Malton Channel	2016	Channel Major Maintenance Dredging Project • Removal of sediment and vegetation from channel	$500,000
Bolton Berm (Dike)	2016	Bolton Berm Hydraulic Assessment and Remediation Study • Flood assessment of berm and structural investigation of dike.	$102,000

State of Repair

The summary of the current state of repair of TRCA flood infrastructure is provided in **Attachment 3**. The CDA defines risk as “the consequence of an adverse event and the probability of such an event occurring”. With finite financial resources, it is not possible to eliminate all risks associated with TRCA dams. However, by using modern engineering analysis and techniques, it is possible to greatly reduce risk. When hazards are high for a structure, the safety requirements are proportionately more rigorous to offset the increased

risk. As the owners of flood protection infrastructure, TRCA has an obligation identify and undertake works to maintain these structures in a state of good repair. With limited funding available for flood infrastructure repairs, TRCA must rank the priority of capital works. This requires that TRCA understand how each structure is performing using engineering judgement in conjunction with criteria provided by the CDA and LRIA.

Using inspections (both internal and external) and engineering reports, each structure's overall condition is assessed to determine the "Structure Condition Assessment". The Structure Condition Assessment ranges from "Very Good" to "Very Poor". The Structure Condition Assessment is a factor in determining the probability of failure which is then used in a risk analysis. Structures with a Poor or Very Poor Structure Condition Assessment have a higher probability of failure. The relationship between Structure Condition Assessment and probability is described in Table 3. The risk assessment provides a quantitative ranking using a probability/consequence matrix.

For state of repair analysis for normal conditions, TRCA evaluates each structure and categorizes them in terms of "probability of failure" and "consequence rating". The probability of failure is based on the structure condition assessment and estimates the likelihood of a deficiency causing the structure to fail. Structure condition considers the overall condition of the structure based on DSR studies and inspection results. Structures are scored from one (1) to five (5). A structure with a score of one (1) is in very good condition with a low probability of failure. A structure with a score of five (5) has a very poor structure condition rating and therefore a very high likelihood of failure. Structure condition ratings are described in Table 3.

Table 3 - Structure Condition Assessment/Probability of Failure Criteria

Condition Rating Score	**Condition**	**Structure Condition Assessment Definition**	**Probability of Failure**
1	Very Good	Well maintained, good condition, new or recently rehabilitated.	Improbable
2	Good	Good condition, few elements exhibit deficiencies.	Not Likely
3	Fair	Some elements exhibit significant deficiencies. Asset requires attention.	Possible
4	Poor	A large portion of the structure exhibits significant deficiencies. Asset mostly below standard and approaching end of service life.	Likely
5	Very Poor	Widespread signs of deterioration. Service and safety are affected.	Very Probable

In addition to the condition rating score, TRCA also considers the consequence to public safety and property should the structure fail or perform below expectations. Known as the

consequence score, the consequence score is determined by estimating property and risk to life during a failure. The score is estimated on a scale between one (1) and five (5). The higher the score, the higher amount of damage would be expected if the structure fails. See Table 4 for a description of consequence rating score criteria.

Table 4 - Consequence Rating Score Criteria

Consequence Rating Score	Consequence Rating Definition
1	Insignificant damage to property.
2	Minor/slight damage to property.
3	Limited damage to property.
4	Significant damage to property. Possible public safety risk.
5	Major risk to property and public safety.

The consequence rating score is multiplied by the condition rating score to determine an overall state of repair/risk ranking score. This score is then placed on a risk ranking matrix to determine the overall risk of the structure. Please see Table 3 for the risk ranking matrix. The results of the risk ranking matrix are included in **Attachment 3** for all TRCA flood infrastructure. Risk ranking is comprised of four (4) categories:

a) Low Risk (1-5, green shading)
b) Moderate Risk (6-10, yellow shading)
c) High Risk (11-15, orange shading)
d) Extreme Risk (16-25, red shading)

The above risk ranking system assists TRCA in understanding where to focus limited capital funds for repairs. Structures with a risk ranking in the High and Very High Category require priority attention to repair the deficiency.

Dams consider several scenarios for risk ranking. This is because dam safety guidelines require that dams must be able to withstand extreme events. Risk ratings for dams include:

- Normal Conditions. Typical conditions dams would be subjected to such as frequent, smaller floods.
- Extreme Flood Conditions. Scenarios where a dam would be subjected to low probability, extreme flood conditions.
- Seismic Risk. Impact of large earthquakes on dams. Considered low probability in southern Ontario.

Determining risk ratings on dams for these events provides a way to prioritize studies and repairs. Dams that have high risk ratings for normal conditions would be at a higher priority for repairs than a dam that may be deficient for rare events.

Dikes and flood control channels are only expected to meet their design requirement and therefore only receive a single risk rating. For example, a channel may be designed to convey a 100-year flood and any larger floods will overtop the banks and there will not be additional risk from the channel failing. Dikes and flood control channels will overtop during extreme flood events and are also not susceptible to seismic risk as the probability of experiencing a flood event at the same time as an earthquake is very low. **Attachment 3**, Table 1 includes the risk ranking for dams for normal, flood failure, and seismic conditions. **Attachment 3,** Table 2, and Table 3 includes risk rankings for flood control channels and dikes respectively.

It should be noted that there are limitations to determining risk. The complexity of forces acting on a structure is difficult to quantify and therefore determining the probability of failure is difficult. Experience, training, and engineering judgment are used to assess the stability and performance of flood infrastructure. Regardless, the process for evaluating structures is somewhat subjective. With the limitations of current inspection techniques, it is not possible to say with certainty that a structure will or will not fail. Inspections can identify potential failure modes, but the complexity of the loads and stresses placed upon structures cannot be precisely measured and so there is a degree of unpredictability in evaluating them.

Table 5 - Risk Ranking Score Matrix

	CONSEQUENCE RATING				
CONDITION RATING/RISK OF FAILURE	**Insignificant damage to property.** **1**	**Minor, slight damage to property.** **2**	**Limited damage to property.** **3**	**Significant damage to property. Possible public safety risk.** **4**	**Major damage to property. Major risk to public safety.** **5**
Very poor condition. Very probable risk of failure. 5	**5**	**10**	**15**	**20**	**25**
Poor condition. Failure likely. 4	**4**	**8**	**12**	**16**	**20**
Fair condition. Possible failure. 3	**3**	**6**	**9**	**12**	**15**
Good condition.	**2**	**4**	**6**	**8**	**10**

Failure not likely. 2					
Very good. Improbable. 1	**1**	**2**	**3**	**4**	**5**

Flood Infrastructure Asset Valuation

Estimated flood infrastructure valuation is approximately $109,000,000 in 2021 dollars. Specifically, asset category valuation breakdown would be:

Table 6 – Asset Valuation by Asset Category

Dams	$75,000,000
Flood Control Channels	$24,000,000
Dikes	$9,000,000

These numbers were derived using original construction costs and inflation. It is very likely that these valuations are conservative and further refinement will be required during TRCA's AMP process.

Significant Changes Since 2020 State of Repair Report

There were two significant changes to the risk ranking of TRCA dams, dikes, and flood control channels since the 2020 Flood Infrastructure State of Repair Report.

1. Bolton Dike's risk ranking was reduced from 8 to 4. This is because TRCA undertook the Bolton Dike Major Maintenance Project in 2021. The dike was raised to meet flood protection requirements and erosion protection was added to the wet side to reduce the risk of failure during extreme flows. Project cost was $1,820,000.
2. Palgrave Dam's risk ranking was reduced from 15 to 10 under the seismic risk scenario. Risk was reduced because an advanced geotechnical investigation was conducted on the embankment found that damage during earthquakes was unlikely. Project cost was approximately $80,000.

Dam safety guidelines consider extreme events in their criteria for determining safe structures; however, it is difficult for dam owners to meet all guidelines because standards keep evolving to reflect the advancement understanding risk and technology. For example, a dam built in 1970 would meet the guidelines for that period of time. As engineering knowledge progresses, the state of practice and standards change, and the dam built in 1970 would not meet standards in 2020. This creates difficulties for dam owners in that dams need to be constantly upgraded and modified to meet the most current safety guidelines. Often these repairs are very costly and difficult to implement. However, because the probability of these extreme events is so low, the priority to mitigate the risk is lower. Priority repairs are focused on deficiencies for normal conditions, however, TRCA is undertaking studies to implement repairs for extreme events as well.

TRCA maintains a list of priority projects to take advantage of funding opportunities. TRCA's list of priority flood infrastructure projects is available in **Attachment 5**. While TRCA is seeking funding from all levels of government and communicating the risk to the public posed by aging flood infrastructure, there is the possibility that only some (or none) of the projects will get the required funding. These projects present a significant liability for TRCA. To address the existing risks until deficiencies can be corrected, TRCA needs to continue improving surveillance, maintenance, risk prioritization and emergency management strategies to offset increasing deterioration of flood infrastructure. Early warning of dangerous or unstable conditions is an effective way of reducing risk to the public but should not replace the need to undertake improvements.

TRCA has made significant progress in upgrading the condition of its flood infrastructure. Numerous projects have been undertaken to restore flood channels and increase dam safety, redundancy, and reliability. Thorough Dam Safety Reviews and engineering studies have helped TRCA understand how the structures rank in terms of risk to the public and how to mitigate this risk. TRCA's Engineering Services team will continue to receive regular training in dam surveillance and public safety, and to monitor changes to dam safety guidelines and the evolution of best practices.

As outlined in the above report, TRCA's inventory of flood infrastructure is aging and, in some cases, has exceeded its expected functional life. There are many forces and natural stresses acting upon these structures that reduce their effectiveness in preventing flooding. TRCA is monitoring these structures and performing capital improvements as they become necessary. However, some mitigation projects are very large in scope and will require substantial funding. Many of these projects will take multiple years to complete because of the complex engineering, design, and approval process required for flood infrastructure repairs. TRCA will pursue funding opportunities such as WECI and DMAF to offset costs for these large projects.

Flooding is a serious threat to the GTA. Weather is unpredictable and extreme events can happen at any time. Climate change science projects a future increase to extreme precipitation events in Canada. Extreme events combined with the dense urbanization of TRCA's watersheds increase the stresses placed upon TRCA's flood infrastructure. To respond to this threat, TRCA will continue to ensure that flood infrastructure is performing at the highest level of protection possible. Rigorous monitoring, well designed repairs, and stable funding sources are all necessary to ensure that TRCA's dams, dikes and channels will continue to provide protection from future flood events.

Relationship to TRCA's 2022-2034 Strategic Plan

This report supports the following Pillars and Outcomes set forth in TRCA's 2023-2034 Strategic Plan:

Pillar 1 Environmental Protection and Hazard Management:

1.1 Deliver provincially mandated services pertaining to flood and erosion hazards

Pillar 4 Service Excellence:

4.2 Provide and manage an efficient and adaptable organization

FINANCIAL DETAILS

Funding for the operation, maintenance, inspection, and repair of TRCA flood infrastructure

is from several sources, as outlined below.

MNRF Section 39

MNRF Section 39 grant funding is provided to Conservation Authorities for natural hazard management. TRCA receives approximately $165,000/year for operation and maintenance of flood infrastructure. This is matched by municipal levy.

Capital Levy

Municipal levy capital funding is provided for flood infrastructure maintenance repair works. Capital levy funding for 2023 was as follows:

Table 7 - *Municipal Capital Levy for Flood infrastructure*

Durham Region	$22,000
York Region	$71,000
Region of Peel	$309,000
City of Toronto	$267,000 (includes Floodworks Enhanced Capital)
Total	$669,000

Water and Erosion Control Infrastructure Funding

The Ministry of Natural Resources and Forestry supports conservation authorities to undertake maintenance activities throughout Ontario with the Water and Erosion Control Infrastructure Program (WECI). Under this program, repairs and studies undertaken on structures are eligible for 50% matching funds from the Province of Ontario. Projects are reviewed and ranked by the WECI Committee which is comprised of representatives from various conservation authorities. Only the highest ranked projects are awarded grants. TRCA applies for WECI funding every year for both repairs and studies. The WECI program has become a critical tool for funding capital improvement projects on TRCA flood infrastructure.

Table 7- *WECI Funding 2016-2023*

WECI Funding received by TRCA 2016-2020	
2016/2017	$230,425
2017/2018	$218,802
2018/2019	$128,023
2019/2020	$126,045
2020/2021	$280,000
2021/2022	$653,286
2022/2023	$639,000
Total	$2,275,590

Disaster Mitigation and Adaptation Fund (DMAF)

DMAF was created to fund large-scale infrastructure projects to implement projects that increase resiliency and reduce risk to the public. It is specifically geared towards risks associated with flooding, wildfires, and droughts. TRCA applied for funding in 2021 for upgrades to Stouffville Dam and Flood Control Channel and Palgrave Dam repairs. TRCA was not successful in this intake but will continue to explore opportunities to leverage this opportunity. The biggest challenge in DMAF funding is the requirement for 60% matching funding from the benefiting municipality. Many smaller municipalities cannot meet the 60% requirement. TRCA has had discussions with the federal government to reduce or eliminate this matching funding requirement to allow more flood mitigation and climate resiliency projects to move forward, especially for smaller municipalities.

DETAILS OF WORK TO BE DONE

TRCA will continue to develop and enhance the programs that keep its flood infrastructure safe and reliable. Specifically:

1. Continue to seek funding opportunities to be able to undertake major capital works that are required on the highest risk structures.
2. Continue the robust inspection programs on flood infrastructure to document deficiencies that could lead to unsafe conditions.
3. Review deficiencies and carry-out studies and repairs to mitigate as appropriate.
4. Update Asset Management Plans to be in line with other TRCA asset reporting standards.
5. Report updates to TRCA' Board of Directors on the state of repair on flood infrastructure in 2025.

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Attachments: 5

Attachment 1: Map of TRCA Flood Infrastructure
Attachment 2: TRCA Flood Infrastructure Location Details and Deficiency List
Attachment 3: TRCA Flood Infrastructure State of Repair and Risk Ranking
Attachment 4: Photographs of various TRCA flood infrastructure and projects
Attachment 5: TRCA Flood Infrastructure Project Priority List