VULNERABILITY ASSESSMENT SUMMARY

Water Infrastructure Systems in the Region of Peel

Prepared for:

Region of Peel
working with you

Prepared by:

Credit Valley Conservation
inspired by nature

Toronto and Region Conservation
for The Living City

Action on Climate Change in Peel Region

The Region of Peel is committed to transitioning to a low carbon and resilient future. The Peel Climate Change Strategy (2011) set the long-term vision for the Region of Peel to work in partnership with lower tier municipalities (Brampton, Mississauga and Caledon) and local Conservation Authorities (Credit Valley Conservation and Toronto and Region Conservation) to reduce community greenhouse gases and minimize local vulnerability to climate change impacts.

The Strategy identified the following six goals:

- Proactive and responsive planning and leadership
- Actions to reduce greenhouse gas emissions
- Targeted and proactive adaptation actions
- Shifting to a green economy
- Increasing awareness of, and engagement in, climate issues throughout Peel
- Ongoing research and adaptive risk management

The Region of Peel commissioned the development of vulnerability assessments to investigate the impacts of climate change on a variety of systems, including agricultural systems, natural systems, community services and assets, and public health. The information gained in these assessments will help identify opportunities for adaptation to climate change and reduction of its negative effects.

Given climate projections that extreme precipitation is likely to become more frequent in coming years, posing potentially significant risks to residents, properties and businesses, a vulnerability assessment of the effects of climate change on water systems within the Region of Peel was completed in 2017. The following summary of that assessment was prepared by Hutchinson Environmental Sciences Ltd. and Shared Value Solutions Ltd., in collaboration with Credit Valley Conservation, Toronto and Region Conservation Authority, the Ontario Climate Consortium, and the Region of Peel.

Note: Please refer to the full technical report for all source material used in the assessment and this summary.

Suggested citation for the full technical report:

Credit Valley Conservation and Aquafor Beech. 2017. **Water Infrastructure Systems Vulnerability to Climate Change in the Region of Peel.** Final Technical Report prepared for the Region of Peel.

Preparing for the Future

Climate change is one of the greatest challenges humans face in the 21st century. As the planet warms, we are witnessing more extreme and variable climate patterns, which are leading to unprecedented impacts for society and natural environments worldwide. The warming trend is no longer reversible, which means that even if we drastically curb greenhouse gas emissions today, we still will continue to experience devastating climate change effects for decades to come. Adaptation is needed at all levels, from local to global, to adjust to the new reality under our changing climate.

Calls to Action

The results of this vulnerability assessment, summarized over the following pages, make it clear that we must act now:

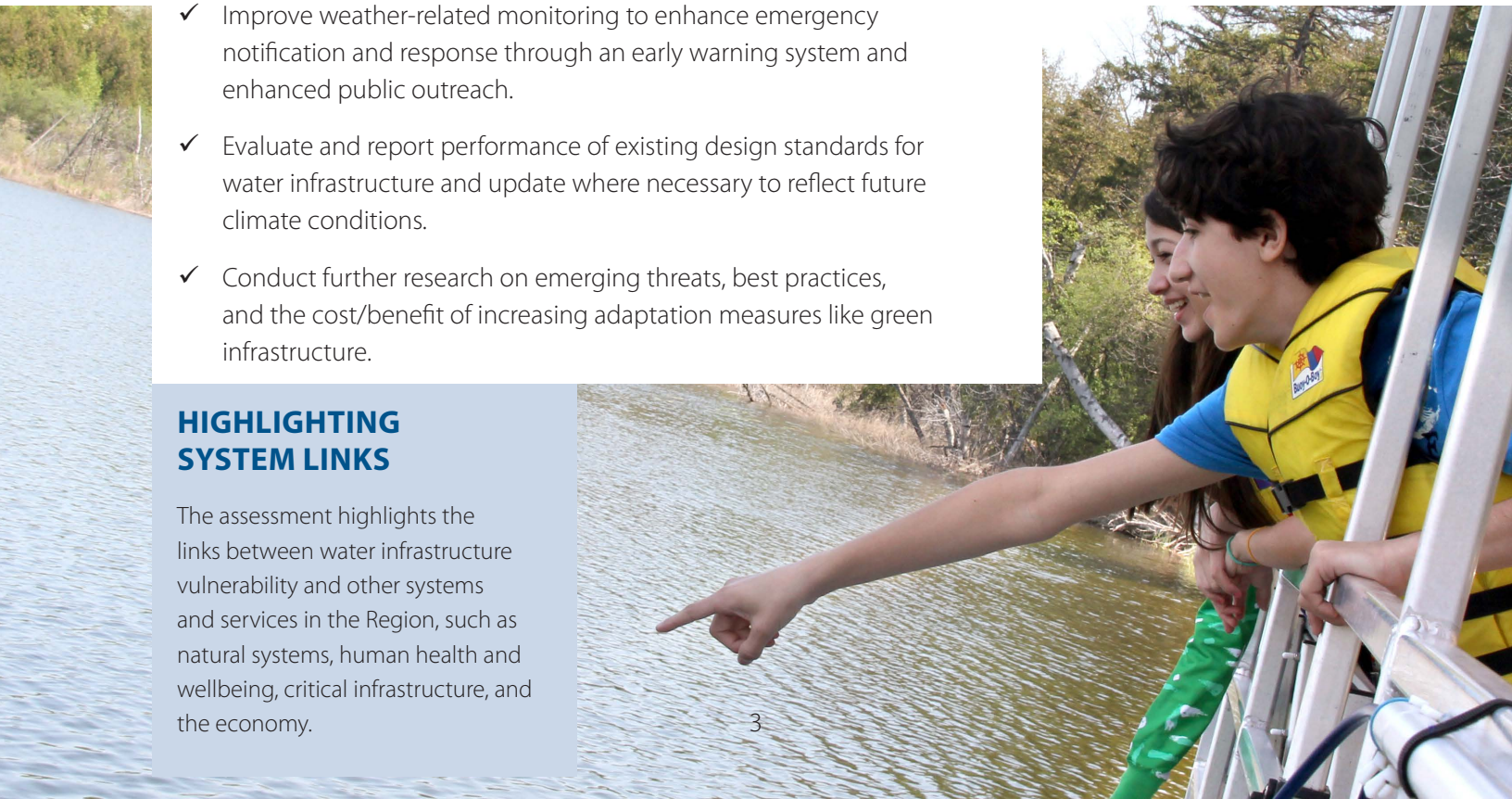
- ✓ Strengthen planning, coordination, and collaboration among the Region of Peel, local municipalities, and Conservation Authorities relating to stormwater management, water-related climate change research, and the development of an integrated watershed management framework and plan.
- ✓ Incorporate climate change planning, and risk and vulnerability assessment, into municipal official plans and infrastructure programs.
- ✓ Improve weather-related monitoring to enhance emergency notification and response through an early warning system and enhanced public outreach.
- ✓ Evaluate and report performance of existing design standards for water infrastructure and update where necessary to reflect future climate conditions.
- ✓ Conduct further research on emerging threats, best practices, and the cost/benefit of increasing adaptation measures like green infrastructure.

The purpose of this assessment is to identify existing and future vulnerabilities to climate change within Peel's water management systems, focusing on

- Watersheds,
- Stormwater infrastructure,
- Wastewater infrastructure, and
- Communal drinking water infrastructure.

HIGHLIGHTING SYSTEM LINKS

The assessment highlights the links between water infrastructure vulnerability and other systems and services in the Region, such as natural systems, human health and wellbeing, critical infrastructure, and the economy.



DEFINING VULNERABILITY TO CLIMATE CHANGE

Many definitions of vulnerability to climate change exist. For the purposes of this assessment the definition from the Intergovernmental Panel on Climate Change was used:

"Vulnerability encompasses... sensitivity or susceptibility to harm and lack of capacity to cope and adapt."

Analysis of Water Survey of Canada streamflow in the Credit River and neighbouring watersheds show annual average streamflow are up to 50% higher in fully urban watercourses than in rural watercourses.

How Does Climate Change Affect Water Infrastructure?

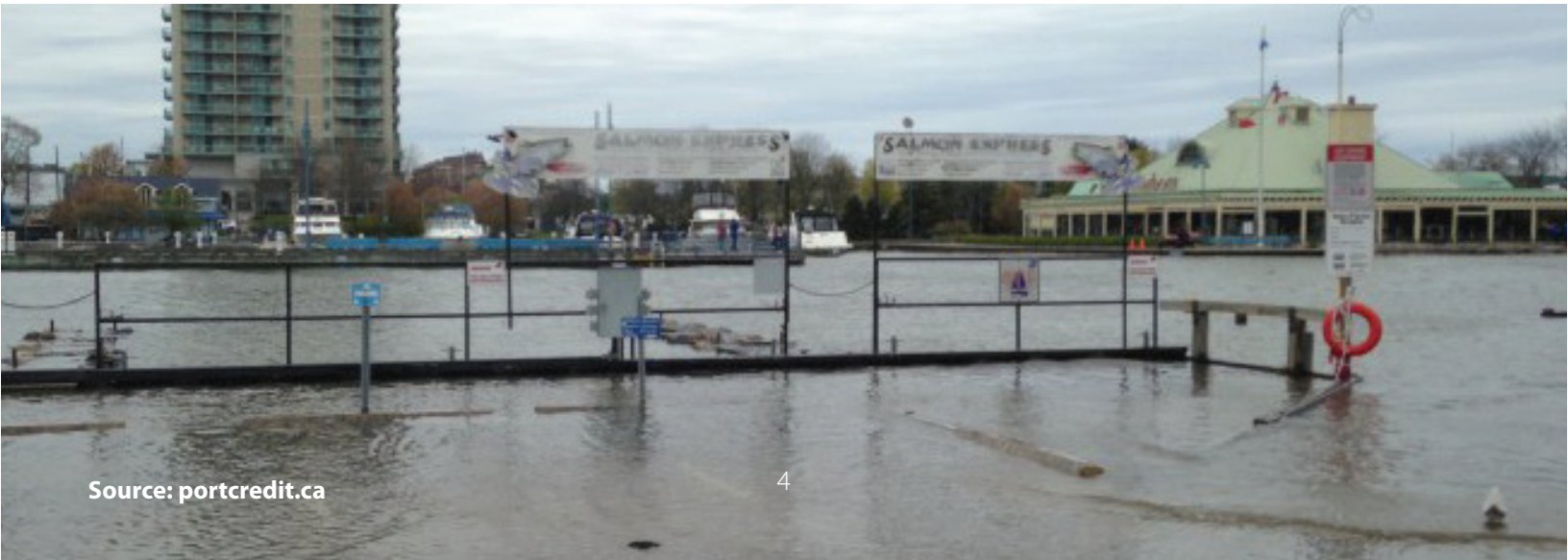
Extreme weather events pose a wide range of risks for public infrastructure and services, the natural environment, and human health and wellbeing. Many of these risks can be traced back to vulnerabilities within water infrastructure systems. Climate change is expected to result in more extreme and variable weather in Peel, including warmer temperatures and shifts in seasonal precipitation patterns. Understanding the state of Peel's water infrastructure systems, as well as how they are connected to the environment and community, will be key to preventing future vulnerabilities under a changing climate.

The Impact of Urbanization on Water Management

Many of the existing vulnerabilities in Peel's water infrastructure systems stem from the location and timing of urban development. Climate change is anticipated to exacerbate the impacts of future growth pressures on existing water infrastructure.

Patterns of Growth

Urbanization in Peel has generally proceeded from the downstream shoreline of Lake Ontario upstream to headwater areas. This pattern means that impacts of future development upstream (including that occurring beyond Peel) may be felt downstream in already developed parts of the Region. For example, analysis of Water Survey of Canada streamflow in the Credit River and neighbouring watersheds show annual average streamflow are up to 50% higher in fully urban watercourses than in rural watercourses.

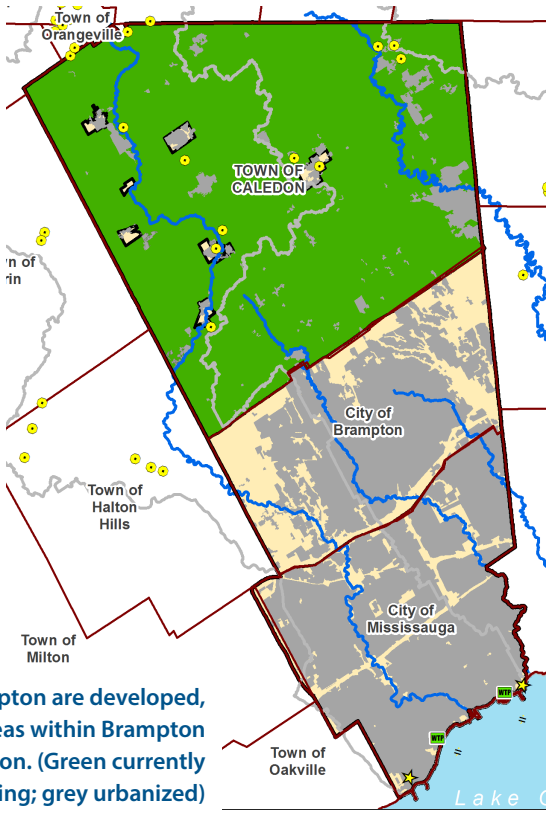


Source: portcredit.ca

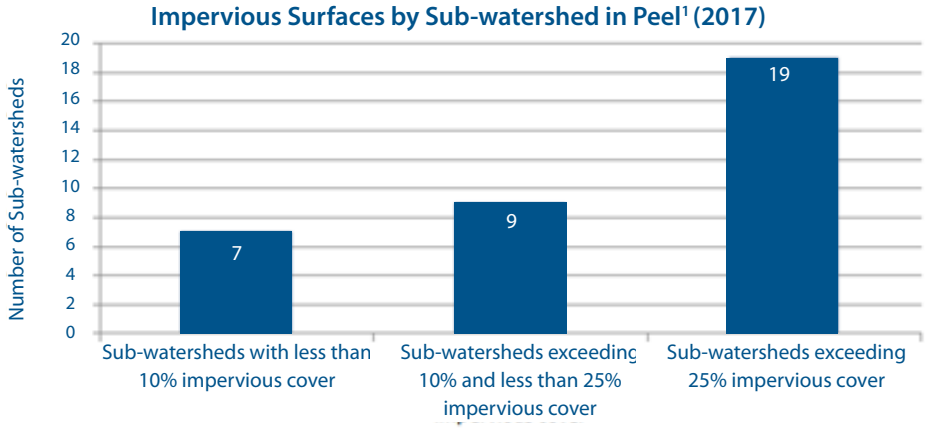
Intensification and redevelopment in existing urban areas can also affect water management through an increase in impervious areas. Local municipalities and conservation authorities should ensure that these additional impacts are reflected in planning policy (such as by requiring specific lot-level controls to handle excess stormwater).

Aging Infrastructure

The age of development can be an indicator of the age of water infrastructure (unless replacement has occurred), and the level of service provided in terms of water quality and water quantity control. This is particularly important for stormwater management infrastructure. Not only has stormwater technology evolved considerably over the last 40 years, but many older areas in Peel were built prior to flood control requirements and thus lack stormwater controls entirely. This discrepancy in stormwater infrastructure and level of service across the Region means that older areas (especially in Mississauga) are highly vulnerable to riverine and urban flooding, as well as increased water quality concerns.



Most of Mississauga and Brampton are developed, while there are Greenbelt areas within Brampton and much of Caledon. (Green currently undeveloped; yellow urbanizing; grey urbanized)



Significant population growth is forecast for the Region.

Compared with 2016, the three local municipalities are expected to increase their resident populations by 23% (Mississauga), 45% (Brampton), and 130% (Caledon) by 2041.

URBANIZATION IN PEEL

Varying levels of urbanization and water infrastructure exist across the Region of Peel:

- Mississauga is largely urbanized, with only small patches of remaining greenspace. Much of Mississauga was built before current flood and water quality control standards were in place.
- Brampton has experienced significant growth over the last two decades and continues to grow while Caledon which is a predominantly rural municipality, has seen some growth in its settlement areas.
- Future development in Peel will be concentrated in the headwaters (Brampton and Caledon), which could potentially exacerbate flooding and water quality issues downstream (Mississauga) if proper stormwater management is not implemented.

From a watershed perspective, Peel is both a downstream and an upstream municipality.

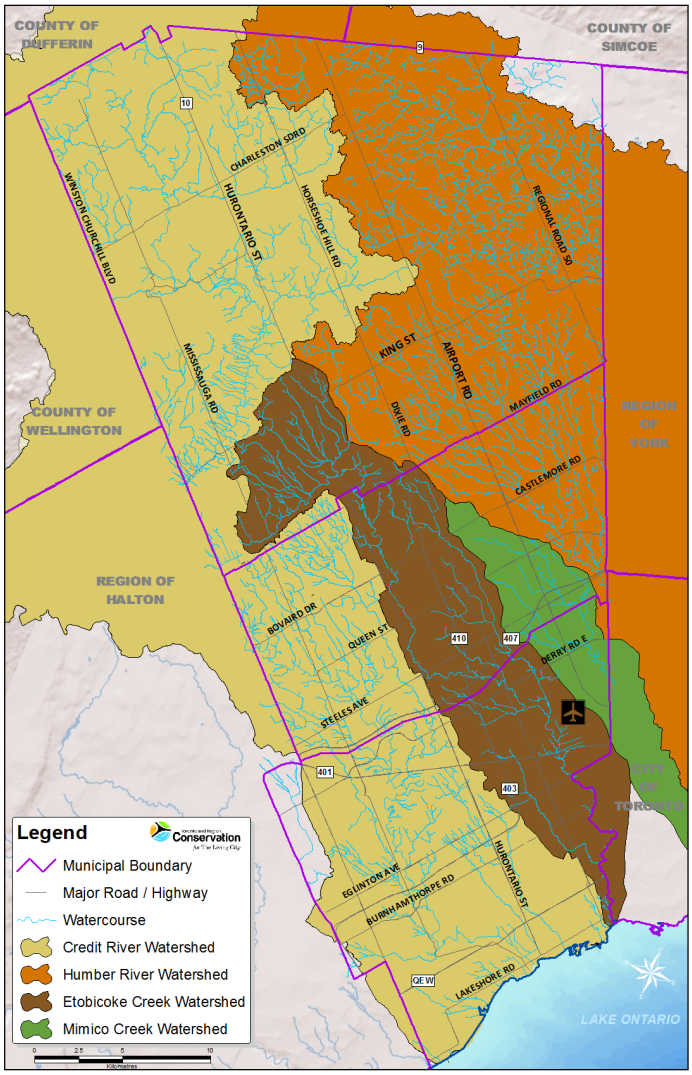
Our Existing Watershed Approach

The Region of Peel straddles several watersheds, and thus its natural water systems extend across political boundaries. As a result, we need to look beyond Peel to fully understand the Region's water-related vulnerabilities.

All watersheds in Peel ultimately discharge to Lake Ontario, either directly or indirectly. Western Peel (under CVC jurisdiction) mainly drains to the Credit River. Eastern Peel (under Toronto and Region Conservation [TRCA] jurisdiction) drains to three watersheds: Etobicoke Creek, Mimico Creek, and the Humber River. Other parts of Peel (including southern Mississauga) drain directly to Lake Ontario.

From a watershed perspective, Peel is both a downstream and an upstream municipality. Western Peel is downstream of urban areas within the Credit River watershed, such as Halton Hills, Orangeville, and Erin. Eastern Peel, meanwhile, is mainly upstream of the Etobicoke Creek, Mimico Creek, and Humber River watersheds.

Water management upstream of Peel directly impacts the Region. Stormwater and treated wastewater from upstream areas is discharged into the Credit River, which then flows into and through Peel. In addition, some water taking for drinking water occurs from groundwater aquifers upstream of Peel Region.



Major Watersheds in Peel Region

EXTREME RAINFALL IN PEEL

In July 2013, a record-breaking storm hit Peel Region, resulting in 125 mm of rainfall within a two-hour period and flooding of more than 2082 basements. Many homeowners experienced property damage and displacement. Electricity and transportation services were interrupted, stranding commuters and disrupting business. Emergency services had difficulty responding to calls because of inundated roadways. Several public buildings were affected by flooding, including at least one elementary school and one of Peel's wastewater treatment facilities. The storm caused over $1 billion in insured damages across the Greater Toronto Area.

The interconnections among water systems in the Region of Peel become clear when viewed from a watershed perspective. Stormwater moves downstream through the watershed and ultimately into Lake Ontario. Treated wastewater discharges to the Credit River and to Lake Ontario's nearshore, the site of two drinking water treatment plants. The cumulative impacts of population growth (both in and upstream of Peel) and climate change are expected to have profound impacts on Peel's water systems in future if not properly managed. Rising urbanization may increase stormwater flows to our rivers, which, coupled with more frequent rainfall predicted under climate change, may elevate the risk of flooding and erosion in the Region.

As populations continue to expand in Peel and surrounding areas, there will be greater demands for water and wastewater services, more impervious areas, and potentially reduced streamflow during drought periods. If not properly managed, streams in Peel may have reduced assimilative capacity, affecting surface water quality, fisheries, recreation and the operation of wastewater treatment plants in the Region.

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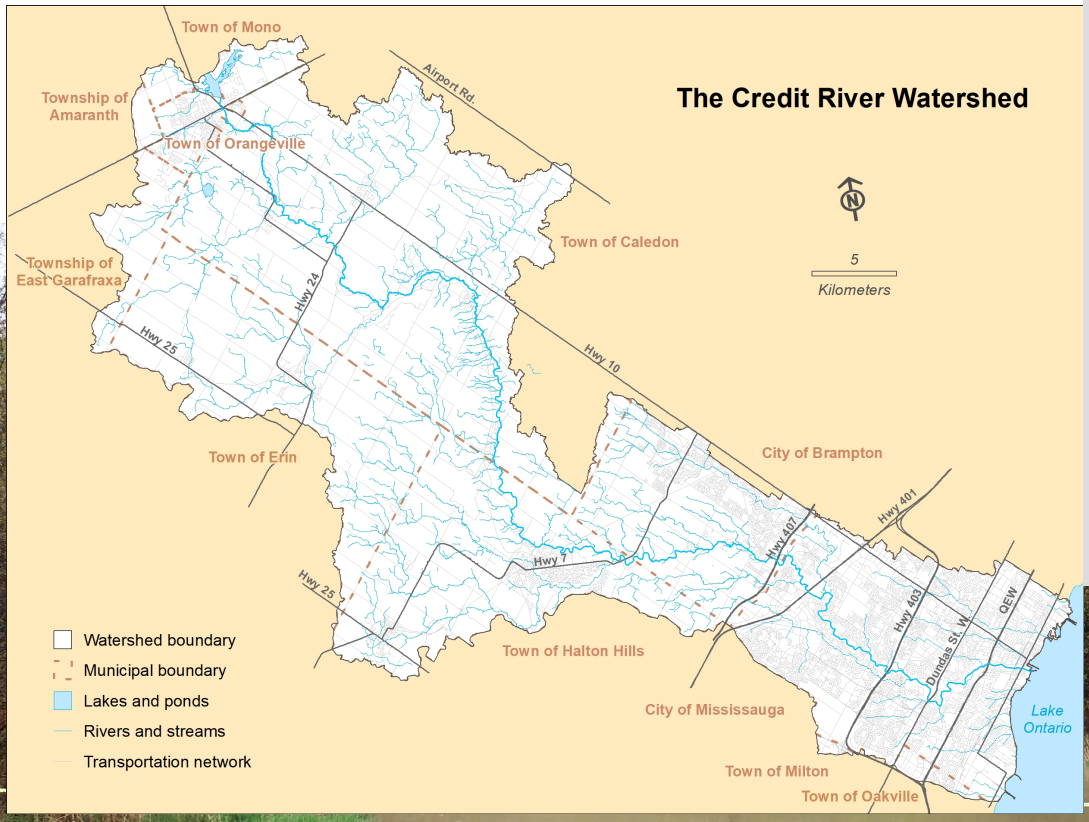

FLOODING IN THE REGION OF PEEL

Two types of flooding can cause problems in Peel:

- Riverine flooding occurs when excess rainfall or snowmelt causes watercourses to overflow and inundate adjacent lands.
- Urban flooding occurs in urban areas independent of riverine flooding, when heavy precipitation overwhelms the stormwater and sanitary systems, resulting in roadway and property damage.

Possible Futures Under Climate Change

Climate Trends in Peel Region

Climate change is already being experienced in the Region of Peel. Monitoring data over the last 50 years shows that Peel has become warmer, with less snowfall and more rainfall since the 1970s. This has increased the risk of adverse impacts to water infrastructure and community wellbeing, such as

- Riverine and urban flooding,
- Pollutant in our waterways and erosion, and
- Algal blooms in our streams and the nearshore of Lake Ontario, impacting recreation and drinking water operations.

Predicting future climate is an evolving science and is therefore not exact, but trends can be forecast based on a range of future greenhouse gas emission scenarios. Under business as usual emissions and development, Peel Region is expected to be hotter at all times of year, with changes to seasonal rainfall patterns, more rainstorms and more heat waves. Winter, spring and fall will likely be wetter, while summer will be drier, but punctuated by heavy rainfall events.

Higher temperatures in summer and early fall will mean more evaporation, lowering water levels and reducing infiltration to recharge shallow groundwater aquifers. Changing winter conditions may result in more or less salt application on roadways, depending on the number of freeze-thaw cycles and ice days that occur into the future. Road de-icing typically increases chloride concentrations in surface runoff, affecting surface water quality and transport of pollutants into Lake Ontario. Less salt may be required in winter to de-ice roadways as temperatures warm over the longer term. In the short term, more frequent freezing rain events, however, may lead to greater salt use. Warming temperatures will also increase opportunities for algal blooms to occur in surface water bodies, which may impact drinking water operations.

Overall, Peel is expected to experience longer spells of unseasonable weather, more powerful storm systems, and a greater incidence of extreme weather events. The Region's climate will also be more variable and unpredictable, with wide fluctuations in conditions, such as potential drought and heavy rainfall. This increased climate variability will pose a challenge for water infrastructure, particularly in terms of planning operational needs and budgets.

FUTURE CLIMATE TRENDS IN PEEL REGION

A study of predicted climate trends for Peel Region found that

By 2050

- Annual mean temperature will rise by 2°C
- The number of extreme heat days (over 30°C) will more than double
- The intensity of extreme storms will increase by 28-51%
- The growing season will be 20% longer than today

By 2080

- Annual mean temperature will rise as much as 5°C from current levels
- There will be up to five times more extreme heat days
- The intensity of extreme storms will increase by 46-90%
- The growing season will be 30% longer than today

Mississauga faced budget and operational challenges when it had to use three times the salt for road de-icing in 2014 (a very cold winter) compared with 2012 (a very warm winter).

What the Storylines Tell Us

Three components of Peel's water infrastructure were examined for the assessment:

- **Stormwater**
- **Wastewater**
- **Drinking water**

The following storylines highlight predominant ways in which climate change will interact with urbanization to exacerbate vulnerabilities in these water systems in the future.

The increased climate variability will pose a challenge for water infrastructure, particularly in terms of planning operational needs and budgets.

Storyline 1: Stormwater

Stormwater is water that runs off land, ultimately ending up in waterbodies such as wetlands, streams and lakes. Proper management of stormwater is important to prevent flooding, stream erosion, and pollution entering the drainage system. In Peel, most stormwater management is the responsibility of local municipalities, although stormwater from regional roads and provincial highways is handled by the Region and the Ontario Ministry of Transportation, respectively and Conservation Authoririte have responsibilities for riverine flooding.

Stormwater management has evolved considerably over the past 40 years in response to rising urbanization and evolving science. Prior to the 1980s there was no flood control, which highlights the major vulnerability of older development in the Region to both urban and riverine flooding.

In the 1980s, management focused on controlling runoff quantity to reduce urban flooding. By the 1990s, water quality and downstream erosion control became important considerations. Today, stormwater management adopts a watershed perspective, aiming to mimic the natural water cycle to reduce flooding and erosion, improve water quality and protect our drinking water supply and natural heritage through techniques such as green infrastructure and Low Impact Development. Stormwater management now focuses on a broad suite of issues including

- Stream morphology and protection of groundwater resources (including drinking water sources),
- Maintenance of dry weather streamflows (including wastewater assimilation), and
- Fish habitat and terrestrial habitat (mainly wetlands).

EXISTING INITIATIVES TO ADDRESS STORMWATER VULNERABILITY

The Region of Peel and its partners are addressing existing and future vulnerability through

- Inspecting, monitoring and maintaining stormwater management practices,
- Updating requirements for stormwater reports in environmental assessments,
- Updating stormwater design criteria for all regional projects,
- Planning to develop stormwater standards and specifications for the Region,
- Planning to identify and improve vulnerable stormwater infrastructure (such as storm sewers in areas prone to flooding),
- Updating floodplain mapping and warning systems, and
- Investigating opportunities to incorporate green infrastructure into planning to reduce runoff in urbanized areas.

Most stormwater ponds that exist in Peel Region do not meet today's best practice standards and many parts of Peel lack these stormwater controls altogether.

Despite significant improvements to Peel's stormwater management over the years, today's infrastructure is designed based on historical climate patterns, not those predicted under climate change. Infrastructure is typically constructed to last 60 to 80 years, so it makes sense to design it to function optimally under future conditions. Vulnerability to climate change may occur in stormwater control (measures used to regulate flows and remove pollutants) and in stormwater conveyance (measures used to drain runoff to waterbodies).

Stormwater Control

Most efforts to control stormwater focus on end-of-pipe measures, such as stormwater management ponds, which are essential for flood mitigation and water quality protection in Peel. These ponds hold urban runoff and allow sediment to settle out before water is released into natural water systems, so timing of discharge can be controlled and the amount of pollutants reduced to downstream aquatic environments.

Due to the age of development, some areas within Peel Region do not meet today's best practice standards for managing stormwater. In Mississauga, for example, only 17% of the total urban area drains to stormwater ponds providing water quality treatment and flood control (62 ponds in 2019). Brampton and Caledon, in comparison, have more stormwater ponds because they developed later than Mississauga. As of 2019 Brampton had 180 ponds (340 are estimated to accommodate full build-out), while Caledon had 64.

Stormwater Conveyance

Stormwater conveyance systems may be at risk in future because they were designed based on historical data, not on climate change projections. Minor drainage systems (such as curbs, gutters, storm sewers and roadside ditches) and major systems (such as drainage swales, channels and trunk storm sewers) in Peel were typically designed to handle historical 1:10 year and 1:100 year storms respectively, while culverts were sized for between 1:25 year and 1:100 year storms. While these standards are consistent with provincial guidance, short duration high intensity rainfall events (like the July 8, 2013 storm) exceed conventional design standards requiring provincial agencies, conservation authorities and municipalities across Canada to evaluate risks and re-evaluate standards.

A PATCHWORK OF STORMWATER CONTROLS

Peel is characterized by a patchwork of stormwater infrastructure. Some older urban areas have little to no stormwater management, which makes them particularly vulnerable to flooding (both riverine and urban), as well as water quality problems. Monitoring of our streams and regular inspection and maintenance of stormwater facilities is critical for reducing flood risks.

Since 1954, Conservation Authorities have regulated Peel's floodplains to keep residents safe and reduce property damage from riverine flooding. Older parts of the Region that were built prior to floodplain management are prone to riverine flooding.

There is an opportunity and need for the Region of Peel to work with Conservation Authorities and lower tier municipalities to address the gaps in stormwater infrastructure across the Region to build resiliency to climate change in future.

Storyline 2: Wastewater

Wastewater systems collect, convey and treat raw sewage before releasing treated effluent to the environment. In Ontario, upper tier municipalities, such as the Region of Peel, are responsible for providing wastewater treatment services to municipal properties.

Peel's wastewater infrastructure consists of over 35,000 km of sanitary sewer main, 36 sewage pumping stations, and three treatment facilities. Clarkson Wastewater Treatment Plant and G. E. Booth (Lakeview) Wastewater Treatment Facility are in Mississauga on the shores of Lake Ontario, and their treated effluent is discharged directly into the lake. Inglewood Communal Wastewater Treatment Plant is in Caledon, and discharges into the Credit River. Peel's wastewater system also provides service to parts of York Region and the City of Toronto. In areas not serviced by the municipal wastewater system (mostly in Caledon and Brampton), there is private sewage disposal through septic systems. This infrastructure is outside the scope of the assessment.

Collection System and Pumping Stations

The historic storm that hit Peel Region in July 2013 highlighted the wastewater collection system's vulnerability to surcharging (due to inflow and infiltration when stormwater inflows into the sanitary sewer system). Extreme rainfall over a short period of time overwhelmed the Region's stormwater system, causing stormwater to spill into the wastewater system through infiltration and inflow. Since sanitary sewers are not designed to accommodate excess stormwater flows, surcharging often leads to basement flooding and bypassing treatment processes in a wastewater plant if effluent exceeds capacity. Indeed, the July 2013 storm led to thousands of flooded basements in Peel, as sanitary effluent entered through floor drains and plumbing fixtures. The risk of sanitary flooding will likely increase as the frequency of intense rainfall events rises under climate change.

In general, Peel's sanitary trunk sewers have the capacity to handle higher flows expected with extreme storm events. However, trunk sewers that cross streams may be vulnerable to erosion, especially in areas where stormwater control is lacking. Sewage pumping stations may also lack capacity to process flows arising from extreme storms. Many stations required removal of sewage after the July 2013 major storm in Peel, costing the Region tens of thousands of dollars in expenses and staff time.

The risk of surcharging and associated flooding will likely increase as the frequency of intense rainfall events rises under climate change.

EXISTING INITIATIVES TO ADDRESS WASTEWATER VULNERABILITY

The Region of Peel is addressing existing and future vulnerability through

- A risk assessment for trunk and wastewater collection systems that will identify vulnerability hotspots,
- An infiltration and inflow monitoring system within sanitary sewers to minimize stormwater is entering the system, and
- Stress test potential impacts of wet weather on different components of the wastewater system.

The G. E. Booth Facility may be particularly vulnerable to sewage bypass, since it receives wastewater from the City of Toronto in addition to Peel. During wet weather events, this facility can receive up to five times more sanitary flow than normal from its Toronto connection.

Lake-based Treatment System

Extreme wet weather can have negative effects on the operation of Peel's treatment facilities on Lake Ontario. Treatment processes may be bypassed if high flows exceed plant capacity, resulting in sewage being discharged before it is fully treated. The G. E. Booth Facility may be particularly vulnerable to sewage bypass, since it receives wastewater from the City of Toronto in addition to Peel. During wet weather events, this facility can receive up to five times more sanitary flow than normal from its Toronto connection.

River-based Treatment System

The Inglewood Wastewater Treatment Plant discharges treated effluent to the Credit River, and as a result depends on adequate streamflow for wastewater assimilation. The facility has approved limits for discharge parameters to maintain water quality in the river, which are derived from historical streamflow conditions at the discharge location. These calculations, however, do not account for reduced streamflow conditions that are expected under future climate conditions, such as drought. Upstream urbanization also may reduce streamflow and impact water quality of the Credit River in future, further threatening the river's assimilative capacity.

EXISTING INITIATIVES TO ADDRESS DRINKING WATER VULNERABILITY

The Region of Peel is addressing existing and future vulnerability through

- Investigating the use of real-time water quality monitoring stations in Lake Ontario to track conditions near drinking water intakes (such as the distribution of total phosphorus and presence of algal blooms), and
- Protecting municipal drinking water supplies under provincial Source Water Protection policies. The Region of Peel also runs a Well Head Protection Program for all municipal wells which includes comprehensive monitoring and an alarm system.

Storyline 3: Drinking Water

The Region is responsibile for drinking water services within Peel. While some private drinking water systems do exist (for example, private groundwater wells), these are outside the scope of this assessment.

The Region of Peel takes its municipal drinking water from Lake Ontario and groundwater sources. Arthur P. Kennedy and Lorne Park Water Treatment Plants on the shores of Lake Ontario, supply residents of Mississauga, Brampton and parts of Caledon with surface water from the lake. In the headwater areas, 15 wells and 10 small-scale groundwater sourced treatment plants supply residents in other parts of the Town of Caledon. An arrangement between Peel and York Region allows residents north of Peel to obtain surface water through an interconnected pipe system which crosses municipal boundaries.

Water Transmission Systems

Peel's water distribution system consists of transmission mains, feeder mains, and service connections. In general, the system is fairly resilient to climate impacts, especially extreme cold events. For example, no watermain breaks were reported during the 2014 winter, one of the

coldest years on record. The system may be vulnerable in certain circumstances, however, such as when transmission mains cross or follow a floodplain and risk becoming exposed due to erosion. Regular inspection by the municipality serve to mitigate these risks.

Lake-based Water Treatment Systems

The water treatment systems on Lake Ontario have shown vulnerability to climate impacts. In 2012, an algal bloom exacerbated by climate conditions in Lake Ontario clogged the intake of the Lorne Park water treatment facility, causing a temporary pump shutdown and damage to 27 intake baskets. The event cost the Region approximately $350,000.

Algal blooms are predicted to increase in frequency and severity in the future under climate change, and their occurrence may be further exacerbated by development and watershed conditions, such as nutrient inputs, reduced streamflow and increased sun exposure of streams. Cyanobacteria (or blue-green algae) is a toxic form of algae that can have serious impacts on drinking water systems. These algae were observed in Peel's Lake Ontario nearshore in 2016 and may represent an emerging problem for the area given the warming conditions.

Extreme rainfall events may also affect lake-based water treatment systems by degrading water quality at water intakes. Following the July 2013 storm, heavy stormwater runoff washed high levels of pollutants into rivers, leading to a strong pollutant plume in Lake Ontario. Fortunately, winds pushed the plume offshore, diluting concentrations in the nearshore where water intakes are located. However, less favourable wind patterns during future extreme storms could pose a challenge for water treatment.

During extreme weather events, electrical power failures may pose a threat, although facilities usually have emergency backup power. A more likely scenario during extreme rainfall events, however, is that sewage bypass may occur, resulting in incomplete treatment at Peel's wastewater treatment plants impacting nearshore water quality at the intakes.

SALTY STREAMS

Long-term monitoring shows that Peel's streams are becoming saltier, with some having levels similar to oceans during winter. High chloride concentrations in streams can be toxic for native aquatic life and promote non-native salt-oriented aquatic species. The culprit is salt used for de-icing roads and parking lots. It is not clear how climate change will affect stream chloride concentrations. In the long-term, road salting may decrease with warmer winters. In the short-term, however, salt use may increase if temperatures fluctuate around freezing.

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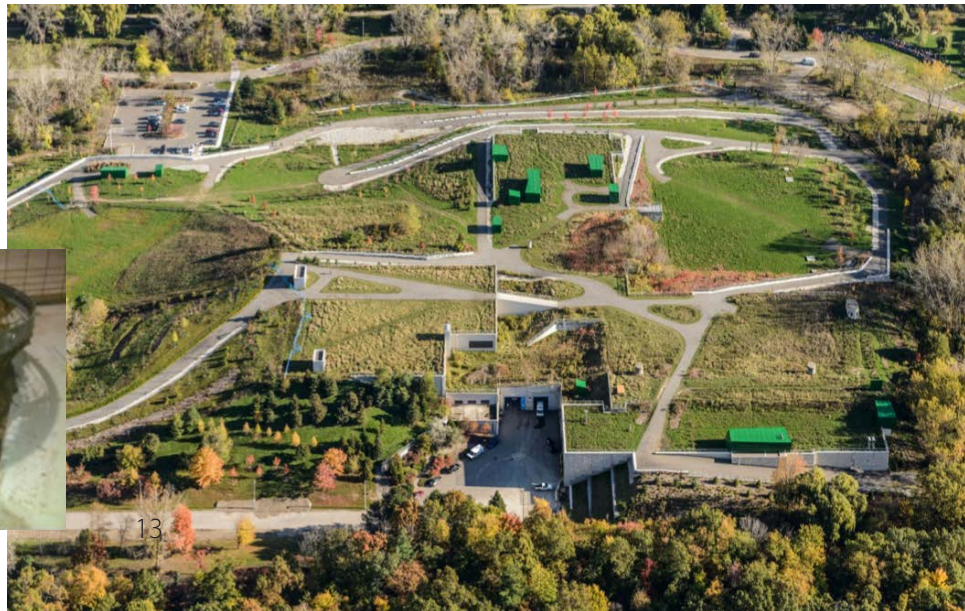


An intake basket from the Lorne Park water treatement plant removed from service due to algae clogging.

Links to Other Systems

Existing and future vulnerability of Peel's water system has cascading effects on other systems in the Region, including the natural environment, human health and wellbeing, critical infrastructure and services, and the economy. Examples of these linkages are listed below. The Region of Peel and its partners have investigated many of these potential impacts in more detail in other vulnerability assessments focusing on natural systems, public health, and community services and assets.

System	Potential Impacts of Water System Vulnerability
Natural Environment	Many native aquatic species cannot survive in warming stream temperatures (like Brook Trout).
	Increased algae growth in streams and nearshore areas can reduce oxygen available for aquatic species.
	Sedimentation impacts aquatic habitat and creates barriers to migration.
	Erosion can destroy riparian vegetation used as buffers and wildlife corridors.
	Increased summer drying may negatively affect the water quantity and quality regarding functions of wetlands.
Human Health and Wellbeing	Flooding can cause injury and death, poor health (e.g., from mold), property damage and dislocation.
	Extreme rainfall events can lead to contamination of drinking water.
	Poor water quality can affect recreational opportunities (such as paddling, swimming, and fishing).
Critical Infrastructure and Services	Flooding can damage critical infrastructure (such as municipal buildings, water and wastewater treatment facilities, schools, and hospitals), as well as roads and linear infrastructure.
	Flooding can disrupt services such as transportation, electricity and telecommunications.
	More frequent and unpredictable extreme rainfall events present new challenges for emergency services.
Economy	Flooding causes damage to private property, businesses and municipal lands and infrastructure.
	Repeat property damage from flooding may increase insurance claims and liability costs.
	Extreme and more variable climate conditions present an operational challenge to municipalities, requiring them to prepare for a broader range of impacts from year to year.
	Climate change affects both the ecosystems and important "civic" services they provide, such as flood mitigation and water quality control. For instance, the economic value of stormwater management services provided by the natural assets (forests, wetlands and open spaces) in the Region of Peel was estimated at around $20 billion stressing the importance of maintaining these services under climate change conditions.

Where Do We Go From Here?

This assessment summarizes key existing and future climate vulnerabilities to water infrastructure. The Region of Peel and its partners have already begun addressing some of these vulnerabilities, but opportunities exist to enhance initiatives that are underway or planned in the near future. For example;

- Strengthen the partnership among regional government, local municipalities, and Conservation Authorities through further collaboration, integration and development of new tools and approaches. Leverage the Flood Resiliency Strategy created through the Peel Community Climate Change Partnership to advance this aim.
- Incorporate climate change planning, and risk and vulnerability assessment, into partner plans and infrastructure programs.
- Improve weather-related monitoring to better integrate climate change considerations into emergency preparedness planning, response and notification.
- Evaluate and report performance for design standards of water infrastructure to ensure they can handle projected future climate conditions.
- Conduct more detailed risk assessments within flood vulnerable areas and explore policy tools to reduce risks in those areas.
- Conduct further research to better understand the impacts of climate change on Peel's water infrastructure, through
  - studies on the potential threat of algae and chloride on the water supply,
  - a review of international best practices for integrated watershed planning, and
  - a cost/benefit analysis and risk assessment of expanding Peel's green infrastructure network.

"No one can do everything, but everyone can do something."

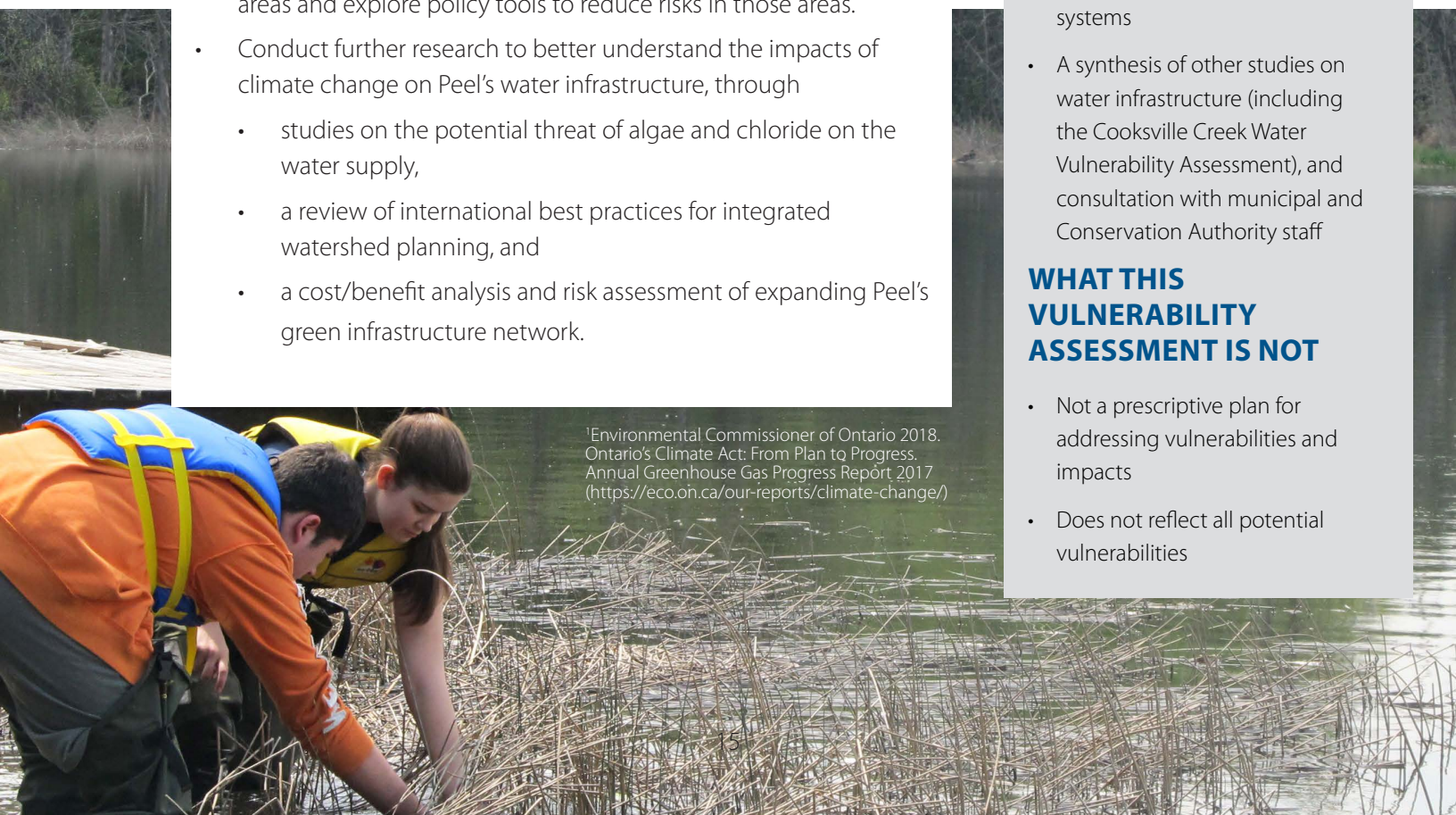
— Dr. Dianne Saxe, Environmental Commissioner of Ontario[1]

WHAT THIS VULNERABILITY ASSESSMENT IS

- Part of the research phase of the adaptive management process Peel and its partners are undertaking to respond to climate change
- An examination of current and future vulnerability of the water systems within Peel, focused on stormwater, wastewater and drinking water infrastructure systems
- A synthesis of other studies on water infrastructure (including the Cooksville Creek Water Vulnerability Assessment), and consultation with municipal and Conservation Authority staff

WHAT THIS VULNERABILITY ASSESSMENT IS NOT

- Not a prescriptive plan for addressing vulnerabilities and impacts
- Does not reflect all potential vulnerabilities



[1]Environmental Commissioner of Ontario 2018. Ontario's Climate Act: From Plan to Progress. Annual Greenhouse Gas Progress Report 2017 (https://eco.on.ca/our-reports/climate-change/)

GLOSSARY

Assimilative Capacity is the ability of a river or lake to receive wastewater or polluted water without impairing its water quality.

End-of-pipe is a method of pollution control that focuses on addressing pollution at the point of discharge into the environment.

Floodplain is a flat area of land next to a stream that experiences periodic flooding.

Green Infrastructure is an approach to water management that incorporates natural and human-made elements providing ecological and hydrological functions and processes. Green infrastructure can include natural heritage features and systems, parklands, stormwater management systems, street trees, forests, natural channels, rain gardens, bioswales, permeable surfaces and green roofs.[1] It is a cost-effective way of supporting the traditional water management infrastructure to achieve flood mitigation and adaptation to climate change, while providing many additional community benefits, such as protection of greenspaces, improved water quality, restoration of wetlands and urban renewal.

Impervious Areas are surfaces covered by material that does absorb water, like pavement (roads, sidewalks, driveways, parking lots). In highly urbanized areas, much of the natural vegetation is replaced by these impervious areas, meaning there is less soil available to absorb water from rain or snow. During extreme weather, huge volumes of stormwater runoff can rapidly develop as a result of impervious areas, leading to a high risk of severe flooding in urban areas.

Low Impact Development is a form of stormwater management that aims to control runoff through use of green infrastructure. It focuses on the conservation and use of natural landscape features to protect water quality, through measures such as reducing impervious areas, preserving existing vegetation, and avoiding construction on permeable soils.

Stream Morphology is the movement and shape of a stream channel, determined by numerous factors including weather, floods and sediment transported downstream.

Water Cycle is the continuous circulation of water from the atmosphere to earth and back again, through evaporation, condensation, precipitation, infiltration (soaking into the ground) and surface runoff.

[1] Provincial Policy Statement 2014 http://www.mah.gov.on.ca/page10679.aspx