PWMF CLIMATE RESILIENCE ASSESSMENT SUMMARY REPORT

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REPORT

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Revision History

Rev	Date	Author	Description of Revision
R00	09-12-2025	Melissa Diamantakos	Initial issue.
R01	18-12-2025	Melissa Diamantakos	Revised to match the changes made to resilience assessment R02.
R02	08-01-2026	Melissa Diamantakos	Revised to match the changes made to resilience assessment R03.
R03	17-03-2026	Melissa Diamantakos	Revised to match the changes made to resilience assessment R05.
R04	30-03-2026	Melissa Diamantakos	Revised to include minor editorial feedback from OPG.

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1.0 Introduction

Ontario Power Generation's (OPG) Pickering Waste Management Facility (PWMF) is located on Williams Treaties First Nations traditional and Treaty Territory, situated on the north shore of Lake Ontario, within the City of Pickering, in the regional municipality of Durham, Ontario. OPG values the relationship it holds with the Williams Treaties First Nations and remains committed to meaningful engagement with them, including in the areas of environmental stewardship and climate change. OPG intends to share this report with First Nations rights holders and encourages sharing feedback and perspectives to meaningfully inform future revisions.

As a climate change leader, one of the guiding principles from the OPG Climate Change Plan [1] includes engaging Indigenous Nations and communities, this reaffirms OPG's commitment to grow long-term, mutually beneficial working relationships with Indigenous Nations and communities near current and future operations. The Plan highlights OPG's climate goals, including the value of nuclear refurbishment and continued operations, as well as an action plan. Additionally, OPG's Reconciliation Action Plan [2] includes a key pillar of Environmental Stewardship, which identifies opportunities to work towards incorporating Indigenous values and priorities within climate assessments, including the gathering and sharing of perspectives about climate change with First Nations communities.

The following was completed as part of a climate resiliency assessment to evaluate the PWMF's nuclear safety under projected climate conditions in 40 years as a result of climate change:

1. Climate Hazard Identification and Projections: Climate hazards identification and characterization constitute a critical step in performing a site climate change resilience assessment. AECOM completed a customized assessment of physical climate hazards for DNGS which has been determined applicable to PNGS and PWMF to better understand historical and projected climate-related risks.
2. Exposure Assessment: A screening assessment was performed to evaluate a list of systems, structures, and components (SSCs) at the PWMF and determined if they met criteria to be considered as systems related to nuclear safety. For these systems, further screening was performed to determine if there were any pathways for climate change-related hazards to impact the components as well as which hazards should be considered for each SSC.
3. Vulnerability Assessment: An evaluation of the nuclear safety-related systems was performed to assess the SSCs for vulnerability to the screened in climate change-related hazards. This involved comparing the climate projections for these hazards to equipment safety tests and design information.

This document provides a summary of the climate resilience assessment performed for PWMF. This report is intended to provide an accessible, yet complete, summary of the evaluation.

1.1 Objectives

The objective of the project was to:

- Determine the SSCs that are safety related following the definition used by OPG and adopted from CSA N292.0-14, "a system, including its components and supports that by failing to perform in accordance with the design intent, has the potential to impact the radiological safety of workers, the public, or the environment".

- Evaluate the safety-related SSCs to determine any which may have a pathway for climate change-related hazards to impact the component(s).
- Consider the above information to present a complete assessment of the nuclear safety of PWMF under climate change-related hazards on a 40-yr timescale. This assessment was presented in the PWMF Climate Change Resilience Assessment.

1.2 Acronyms

DSCs – Dry Storage Containers

DSMs – Dry Storage Modules

EPRI – Electric Power Research Institute

EWE – Extreme Weather Events

GHG – Greenhouse Gases

IPCC – Intergovernmental Panel on Climate Change

OPG – Ontario Power Generation

PCSS – Pickering Component Storage Structure

PWMF – Pickering Waste Management Facility

RCP – Regional Climate Projection

RWCs – Retube Waste Containers

SSCs - Systems, Structures, and Components

2.0 Climate Hazards

The changing climate poses potential threats and uncertainties to existing and planned infrastructure. Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred. Human-caused climate change is already affecting many weather and climate extremes in every region across the globe. Due to the changes both globally and regionally, design parameters based on historical weather and climate information might no longer be sufficient and may need to be revised to consider local climate change.

Climate change is caused by ongoing emissions of anthropogenic greenhouse gases (GHG), large-scale transformation of land use, and lifestyle and patterns of consumption and production across regions. As a result of these circumstances, Canada's climate has been changing. The impacts of climate change include an increase in mean ambient air and water temperatures, changes in precipitation patterns, and increases in the frequency and severity of extreme weather events [3]. These changes in weather patterns and extreme weather events have the potential to impact nuclear operations if not understood and addressed adequately.

Based on the site location, the climate change-related hazards identified in Table 1 were determined by OPG.

Table 1. List of Climate Change-Related Hazards Grouped by Priority

High Priority	Medium Priority	Low Priority
Gradual Climate Change		
Increasing ambient temperature	Low lake/river-level and hydrological drought	Air quality (pollution)
Increasing water temperature	Acidification (of the ocean or lake)	Humidity
Total precipitation	-	-
Extreme Weather Events (EWEs)		
Extreme high-water temperature	Blizzard/snowstorm	Extreme soil temperature
Extreme low water temperature	Cold spell	Extreme air pressure
Flooding due to rising lake water level	Downburst/derecho	Flash freeze
Flooding due to runoff, riverine flooding, local site area flooding (including snow melt)	Extra-tropical storm	-
Flooding due to waves, storm surges, seiche, meteotsunami, waterspout, and tsunami	Extreme snowfall	-
Extreme high air temperature	Extreme snowpack/snow accumulation	-
Extreme low air temperature	Heat wave	-
Extreme rainfall (probable maximum precipitation)	Hurricane/typhoon	-
Tornado	Ice storm/freezing rain/sleet	-
Other Natural External Events		
Flooding due to high groundwater	-	Landslide/slope instability
Flooding due to sudden release of water from natural or artificial storage	-	Soil frost

High Priority	Medium Priority	Low Priority
Flooding due to upstream obstruction upstream of river channels (by landslides, ice jams, logs, debris, or volcanic materials)	-	Coastal erosion (erosion by water)
-	-	Frazil ice/ice barrier/surface ice (on river or lake)
-	-	Biofouling

The assessments in this project were evaluated only against the high and medium priority climate hazards. Some climate change-related hazards were not considered as their projections indicated that the future climate-related hazards would remain similar to historic records or become less severe.

2.1 Climate Projections

The climate projection dataset is a customized assessment of physical climate hazards for both Pickering Nuclear Generating Station (including PWMF) and Darlington Nuclear Generating Station sites to understand the historical and projected climate-related risks. The dataset presents historical and projected climate data for the following hazards including but not limited to: temperature (including projected maximums and minimums, extreme heat, and extreme cold), precipitation (including annual total and 10-year return period events), snowfall (annual maximum snowpack and 10-year return period events), lake water temperature, and data for hurricanes.

The PNGS Climate Change Bounding Analysis memo provided the bounding/threshold values for each climate change-related hazard selected, their source, climate projections associated under the Intergovernmental Panel on Climate Change's (IPCC) Regional Climate Projection (RCP) 8.5 and RCP4.5[1] scenarios, and justification for their selection. Where a bounding/threshold value could not be identified, a rationale was provided. The bounding/threshold values for RCP4.5 and RCP8.5 were used to assess the impact of climate change-related hazards on the exposed safety related SSCs.

Climate-specific projections were provided for the climate hazards in Table 1 for the following time periods, where data is available:

- Historical: Based on available data. The period of 1981-2010 was used for the majority of climate hazards except for high water temperature measurements which has a historical data range of 2017-2022.
- 40-year data: Data projections for 2065. The period of 2051-2080 was used for a 2065 midpoint.

All climate projections used in this project are shown in Appendix A.

[1] The IPCC has defined four RCPs which describe different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions, and land use leading to specific radiative forcing characteristics extending up to the year 2100. The RCPs are used for making projections based on the factors which primarily drive anthropogenic GHG emissions: population size, economic activity, lifestyle, energy use, land use patterns, technology, and climate policy. The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5) [3].

3.0 Climate Exposure and Vulnerability Assessments

3.1 Summary

The exposure assessment evaluated a list of PWMF SSCs and determined if they met criteria for being safety-related systems and then if there were possible pathways for interaction with climate change-related hazards. Additionally, the exposure assessment identified specific climate change-related hazards for each SSC to be assessed. This exposure assessment limited the SSCs screened 'in' to those that are safety related and meet the function of "control, cool, contain" for nuclear materials.

The vulnerability assessment was performed using climate projection data for 2065, and it confirmed that for the hazards and SSCs assessed in this study, these projected climate conditions are not expected to pose a risk to nuclear safety. The design parameters for the safety-related SSCs are sufficiently robust to preclude impact from the climate change-related hazards on a 40-year timescale. An increase in severity or frequency of extreme weather events, such as storm conditions, increases the likelihood of impacts to the SSCs but does not necessarily indicate failure during a severe weather event. It is expected that there will be sufficient time to respond to potential interactions of the SSCs with more severe events resulting from changing climate conditions.

3.2 Methodology

Evaluating and managing the risk of climate change consists of a sequence of assessments. It begins with an assessment of the climate related hazards, evaluating potential changes in physical climate conditions (e.g., increase in lake temperature or ambient temperature) and is followed by evaluating the impact on the exposed systems [4]. The climate assessment started with a preliminary list of systems developed by reviewing OPG documentation, a site walkdown, and conversations with OPG. This preliminary list of systems and the list of climate hazards provided in Table 1 were used to perform an assessment as follows:

1. Screened the list of systems for any which are systems related to safety. Using the CSA N292.0-14 definition this means "a system …that by failing to perform in accordance with the design intent, has the potential to impact the radiological safety of workers, the public, or the environment". SSCs important to nuclear safety were identified by searching through relevant OPG documentation.
2. Of the nuclear safety related systems that were screened in during the previous step, screening was performed to determine any SSCs which have pathways for interaction with climate hazards and to screen in/out relevant hazards specific to each SSC. The existing list of climate hazards includes external hazards resulting from gradual climate change, EWEs, and other natural external events. Only the hazards identified as high- and medium-priority were considered in this assessment.
3. Following the screening, any systems that were screened in as important to nuclear safety were then evaluated for potential consequences of exposure to the screened in relevant climate change-related hazards under a changing climate. For any SSCs where vulnerabilities to the climate change-related hazards were identified preliminary options for responding or adapting to manage the impact were provided.

3.3 Climate Assessment

The first step of the climate assessment was to compile a list of PWMF SSCs to function as the basis of SSCs that would be considered in this report. This list of SSCs were identified by performing a documentation review of facility safety reports, design manuals, and system drawings. The list of SSCs was also determined through conversations with OPG and the PWMF site walkdown.

This list of SSCs was further screened to identify any SSCs which might be important for nuclear safety i.e., a “safety related system”, and specifically to the functions of “control, cool, and contain”. The definition of a safety-related system used by OPG and taken from CSA N292.0-14 is, “a system, including its components and supports that by failing to perform in accordance with the design intent, has the potential to impact the radiological safety of workers, the public, or the environment”. These SSCs can be seen in Table 2.

Table 2: List of Safety Related Systems

System	Brief Description
Dry Storage Containers (DSCs)	The DSCs, located in the DSC processing building and storage buildings, provide shielding and containment of radioactive contents during normal and accident conditions.
DSC Transfer Clamp	DSC transfer clamps which secure the DSC lid during on-site transfer of the DSCs from the Irradiated Fuel Bay to the DSC processing building prior to seal welding.
Dry Storage Modules (DSMs)	Concrete structures located in the Retube Component Storage fenced area provide shielding and containment of radioactive contents during both normal and accident conditions.
Retube Waste Containers (RWCs)	New storage containers which will contain Intermediate Level Waste and be stored within the new Pickering Component Storage Structure (PCSS) building.

The screening resulted in only the Dry Storage Containers (DSCs), DSC transfer clamp, Dry Storage Modules (DSMs), and Retube Waste Containers (RWCs) being identified as nuclear safety related systems. These SSCs were considered in the remainder of this resiliency assessment. The remaining SSCs were screened out as they were not determined to perform a safety function which prevents or mitigates the release of radioactive emissions from the facility.

Screened in SSCs were evaluated to identify any equipment or components of the systems which had a pathway for interaction with a hazard. Within one SSC not all equipment must have the same pathways or be affected by the same hazards. For this assessment the SSCs being assessed were each evaluated as a single item. This means any hazards identified for a portion of an SSC were considered to impact the system as a whole. SSCs determined to be impacted by climate change-related hazards were screened in for a vulnerability assessment. SSCs which were determined to not have any pathway for interaction or be impacted by any climate change-related hazard were screened out for further consideration. The four safety-related SSCs (DSCs, DSC transfer clamp, DSMs, and RWCs) were determined to have pathways for interaction with climate hazards as they are either located outside or are exposed to outside conditions during their lifespan. For each of these SSCs all of the high- and medium-priority hazards were screened in as conditions which may interact with the SSCs, with the exclusion of hazards related to bodies of water and groundwater:

- lake water temperature;
- flooding due to rising lake water level;
- flooding due to waves, storm surges, seiche, meteotsunami, waterspout, and tsunami;
- flooding due to high groundwater;
- flooding due to sudden release of water from natural or artificial storage;
- flooding due to upstream obstruction upstream of river channels (by landslides, ice jams, logs, debris, or volcanic materials);
- low lake/river-level and hydrological drought; and
- acidification (of the ocean or lake).

The four SSCs and screened in climate change-related hazards were then assessed further in the vulnerability assessment.

This vulnerability assessment for existing SSCs was performed by reviewing documentation for the facility including the description, design, test parameters, and radiological safety assessment of the DSCs, DSC Transfer Clamp, and DSMs during various cases and considering the applicability of the results/information to screened in climate change-related hazards. The safety assessment and testing parameters provided information on the integrity and stability of the DSCs, DSC Transfer Clamp, and DSMs for different hazard scenarios such as high ambient temperatures (from nearby fires), high winds, seismic activity, tornado missiles, etc. The conditions described in the safety assessments were more severe in comparison with the 2065 climate projections, and therefore the SSCs were determined to be radiologically safe in all conditions. This assessment demonstrated that the DSCs, DSC Transfer Clamp, and DSMs would be able to withstand climate change-related hazards on a 40-year timescale, based on the projections, and that nuclear safety of these SSCs would not be impacted by climate change-related hazards on this timescale.

The vulnerability assessment for the planned RWCs was performed by reviewing the design requirements of the RWCs and existing procedures and design of PWMF. It is assumed that existing procedures at the PWMF for safe transport of DSCs and information about site drainage and potential flooding of existing PWMF buildings will be applicable to the PCSS site and onsite transport of RWCs. The design requirements were also assumed to reflect the features the constructed RWCs would meet or exceed to enable this preliminary climate resiliency assessment. These assumptions and RWC design requirements provided information on the intended integrity and stability of the RWC for different hazard scenarios such as high ambient temperatures (70°C design), high winds, tornado missiles, etc. This assessment concluded that the RWCs are expected to withstand climate change-related hazards on a 40-year timescale, based on the climate projections, assumptions, and design requirements, and that nuclear safety of these SSCs would not be impacted by climate change-related hazards on this timescale.

The existing and planned safety related SSCs have therefore been determined to not be vulnerable to climate change-related hazards on a 40-year timescale, and there is no anticipated impact to nuclear safety as a result of PWMF SSCs experiencing the effects of climate change.

4.0 Conclusions

A list of important SSCs for the PWMF was developed in coordination with OPG, pertinent facility documentation, and a site walkdown. This list was then evaluated to identify SSCs considered safety related, defined as those that, if they fail to perform in accordance with their design intent, could impact- the radiological safety of workers, the public, or the environment. This screening identified four safety related SSCs at PWMF to be further assessed: DSCs, DSC Transfer Clamp, DSMs, and RWCs. The next step in the exposure assessment was to evaluate these SSCs to determine if there was a pathway for climate change-related hazards to impact the systems, and which hazards should be screened in on an individual SSC level. Each of the four safety related SSCs was determined to have pathways for interaction with the high- and medium- priority climate change-related hazards, with the exception of hazards related to bodies of water and groundwater; these hazards were screened in for further evaluation in the vulnerability assessment.

The vulnerability assessment evaluated the nuclear safety related SSCs against the equipment specific climate change-related hazards to determine potential consequences of exposure to a changing climate. This was determined by searching through applicable safety and design documentation from the PWMF. The DSCs, DSC Transfer Clamp, and DSMs are designed to maintain radiological safety in all conditions, as described by the testing and performance criteria for these SSCs. The conditions described in the safety assessments for DSCs, DSC Transfer Clamp, and DSMs are more severe in comparison with the 2065 climate projections and as such the safety related systems discussed are expected to withstand climate change-related hazards on a 40-year timescale. Similarly, the described assumptions and design requirements of the RWC supported preliminary conclusions that this SSC is expected to withstand climate change-related hazards on a 40-year timescale. This vulnerability assessment concluded that the nuclear safety related SSCs, including the DSCs, DSC Transfer Clamp, DSMs, and RWCs are not vulnerable to projected climate change related hazards. The evaluation confirms that these SSCs will continue to perform their safety functions, pursuant to adherence with the assumptions and design requirements, and the nuclear safety analysis for the PWMF facility will remain valid on a 40-yr timescale.

Climate change is seen as a gradual change which is likely to increase the severity of hazards already evaluated and screened routinely. Routine preventative maintenance programs and measures to monitor the daily operation of the facility, as well as procedures for severe weather emergency preparedness as applicable, are seen as sufficient to discover and mitigate changes being brought on to PWMF by climate change.

5.0 References

[1] OPG, “OPG Climate Change Plan”, https://www.opg.com/documents/opg-climate-change-plan-2020/, Accessed August 20, 2025.

[2] OPG, “Reconciliation Action Plan June 2024”, https://www.opg.com/documents/reconciliation-action-plan-2023-annual-report-pdf/, Accessed August 20, 2025.

[3] IPCC, "Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]," IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001, 2023.

[4] EPRI, “Climate Vulnerability Assessment Guidance for Nuclear Power Plants”, 3002023814, Palo Alto CA, 2022.

[5] United Nations Office for Disaster Risk Reduction, "Downburst," no date. [Online]. Available: https://www.undrr.org/understanding-disaster-risk/terminology/hips/mh0001. [Accessed June 2025].

[6] United Nations Office for Disaster Risk Reduction, "Derecho," no date. [Online]. Available: https://www.undrr.org/understanding-disaster-risk/terminology/hips/mh0053. [Accessed June 2025].

[7] United Nations Office for Disaster Risk Reduction, “Extra-tropical Cyclone”, no date. Available: https://www.undrr.org/understanding-disaster-risk/terminology/hips/mh0031. Accessed August 20, 2025.

Appendix A: Climate Hazard Projections and Historical Data

A.1 High Air Temperature

A.1.1 Projections

The climate change-related hazards associated with high air temperature are increasing ambient temperature, extreme high air temperature, and heat wave. All three hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Increasing Ambient Temperature

The ambient temperature includes the daily minimum, mean, and maximum temperatures averaged over each time horizon.

Average Daily Temp (°C)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Minimum	4.1	5.0	5.3	6.0	7.4
Mean	8.2	9.7	9.9	10.6	11.9
Maximum	12.2	14.3	14.4	15.1	16.5

Extreme High Air Temperature

The extreme high air temperature is the averaged annual maximum air temperature for the period.

Average Annual Temp (°C)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Maximum	35.9	37.2	37.2	38.2	40.1

Heat Wave

A heatwave is defined as at least 3 consecutive days with daily maximum temperatures above 30°C. The heat wave projections data is the annual number heatwaves averaged over each time horizon.

Average Annual Heatwaves (#)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	0.4	2.6	2.8	3.5	5.2

A.1.2 Assessment

Considering historical data and projections over a 40-year timescale (to 2065), annual mean ambient air temperatures are anticipated to increase by 2.4 - 3.7°C, annual maximum ambient air temperatures by 2.9 - 4.3°C, annual maximum extreme air temperature by 2.3 - 4.2°C, and the annual number of heat waves by 3.1 - 4.8. For both emission scenarios, average ambient air temperatures, extreme high air temperatures, and heat wave incidences will continue to increase, with the highest data seen for all hazards in 2051-2080 for RCP8.5.

A.2 Low Air Temperature

A.2.1 Projections

The climate change-related hazards associated with low air temperature are extreme low air temperature and cold spell. These hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Extreme Low Air Temperature

The extreme low air temperature is the averaged annual minimum air temperature for the period.

Average Annual Temp (°C)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Minimum	-27.7	-24.4	-24.4	-22.1	-19.7

Cold Spell

A cold spell is defined as at least 3 consecutive days with daily minimum temperatures below -20°C. The cold spell projections data is the probability of annual number of cold spells averaged over each time horizon.

Average Annual Cold Spells (%)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	0	2.7	3	0	0

A.2.2 Assessment

Considering historical data and projections over a 40-year timescale (to 2065), annual minimum extreme air temperatures are anticipated to increase by 5.6 - 8°C and the probability of cold spells will likely display minimal increase over a mid-term period and then return to historic levels. For both emission scenarios, low air temperatures are anticipated to display a general warming trend, with climate data remaining the same as historic levels or warmer in 2051-2080. As the severity of low air temperatures is projected to decrease over the life of the facility there is unlikely to be a significant hazard to PWMF through interactions with this climate hazard under the effects of climate change.

A.3 High Water Temperature

A.3.1 Projections

The climate change-related hazards associated with water temperature are increasing water temperature and extreme high water temperature. These hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Increasing Water Temperature

The increasing water temperature is the average of the annual mean water temperature for each time period based on projected air temperatures.

Average Annual Water Temp (°C)	Historical (2017-2022)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	10.4	11.1	11.6	11.8	13.5

Extreme High Water Temperature

Extreme high water temperature projections are the annual maximum measured or predicted water temperatures for the period.

Annual Water Temp (°C)	Historical (2017-2022)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Maximum	24.3	24.9	25.6	25.5	27.4

A.3.2 Assessment

Considering historical data and projections over a 40-year timescale (to 2065), annual mean and maximum extreme air temperatures are anticipated to increase across all time periods. For both emission scenarios, maximum/mean water temperatures are anticipated to display a general warming trend, with the highest data seen for both hazards in 2051-2080 for RCP8.5. Based on the projections, the maximum and mean annual lake water temperatures will continue to increase. On a 40-year timescale, climate change is expected to raise the maximum lake temperatures by ~3°C.

A.4 Precipitation

A.4.1 Projections

The climate change-related hazards associated with precipitation are annual total precipitation and extreme rainfall. These hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Total Precipitation

Total precipitation is defined as the sum of rainfall and snowfall; the projections are the averages of the annual total precipitation for each time period.

Annual Total Precipitation (mm)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	862	853	871	892	890

Extreme Rainfall

Extreme rainfall is defined as the annual maximum of the daily rainfall for a 10-yr return period averaged across each time period.

Annual Maximum Daily Rainfall (mm)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
10-yr return level	64.1	75.1	73.2	80.0	84.9

A.4.2 Assessment

The highest 40-year projection for annual precipitation (892 mm) is above the historical annual precipitation levels (862 mm); this represents an increase of 30 mm of precipitation falling over the course of a year. The extreme rainfall is the annual maximum of the daily rainfall for the period. The 10-year return period event is an extreme rainfall event that occurs once in 10 years, or has a 10% chance of being exceeded in a given year. On a 40-year timescale, climate change is expected to raise the annual extreme rainfall (based on a 10-yr return level event) by ~21 mm.

A.5 Snowfall

A.5.1 Projections

The climate change-related hazards associated with snowfall are extreme snowfall, blizzard/snowstorm, and extreme snowpack/snow accumulation. These hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Extreme Snowfall

Extreme snowfall is defined as the annual maximum of the daily snowfall for a 10-yr return period averaged across each time period.

No projections data is available for this climate hazard.

Blizzard/Snowstorm

The frequency of snowstorms north of Lake Ontario is projected to decrease by 20 to 30% in the RCP8.5 scenario as more winter precipitation will shift to rainfall. Due to limited predictability, it is currently not possible to provide projections regarding changing in intensity of blizzards and snowstorms with climate change.

Extreme Snowpack/Snow Accumulation

Extreme Snowpack/Snow Accumulation is defined as the annual maximum snowpack/snow accumulation averaged across each time period.

Annual Maximum Snow on Ground (cm)	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	51	87.6	46.5	66.4	42.7

A.5.2 Assessment

Climate projections indicate that under the RCP8.5 emission scenario the frequency of blizzards/snowstorms and volume of snow accumulation will decrease on a 40-yr timescale. Under the RCP4.5 emission scenario, which represents the intermediate scenario, an increase to extreme snowpack is anticipated on a 40-yr timescale. The RCP4.5 emission scenario is used for this assessment, and the three climate hazards are assessed together under snowfall hazards. These projections indicate that snowfall events will progressively become more severe and may increase impacts to the facility from snow accumulation and heavy snowfall events.

A.6 Acidification of the Lake

A.6.1 Projections

<u>Acidification of the Lake</u>

Acidification is defined as the measured and projected mean annual pH for the Great Lakes averaged across the time periods.

Average Annual pH	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	8.44	-	8.33	-	8.20

A.6.2 Assessment

The historic mean pH of the lake is 8.44. This is projected to drop to 8.33 for 2021-2050 and a low of 8.20 on a 40-yr timescale. These represent a 29% and a 74% increase in the acidity of the water, respectively, compared to the historic mean pH. Changing pH levels of the lake could impact material selection and impact the lifespan of existing materials.

A.7 Flooding (runoff, riverine flooding, local site area flooding, rising lake water level)

A.7.1 Projections

<u>Flooding (runoff, riverine flooding, local site area flooding, rising lake water level)</u>

No climate data projections were considered to assess the impacts of this climate hazard on a 40-yr timescale. Considering the site layout and topography there is no pathway for interactions between PWMF and these hazards.

A.7.2 Assessment

Extreme rainfall events can lead to flooding when either the design limits of the storm sewer systems are exceeded or when the soils cannot absorb the rainfall fast enough. Ponding of water onsite could enter station buildings and potentially fail plant equipment.

For the purposes of this assessment, considering the site characteristics, this hazard is evaluated as a consequence of extreme rainfall and has been included under Precipitation.

A.8 High Winds

A.8.1 Projections

The climate change-related hazards associated with High Winds are Tornadoes, Downburst/Derecho, Extra-Tropical Storms, and Hurricane/Typhoon. These hazards will have similar impacts on facility equipment and are therefore assessed together when applicable.

Tornado

Projections for this hazard are not available as conclusive statements about the change in frequency or intensity of tornadoes with climate change is not possible because of the limited predictability of tornadoes, and as there is not a sufficient understanding of historical tornado events or tornado science to form projections.

Downburst/Derecho

Downbursts are high wind events that involve a powerful wind which descends from a thunderstorm and spreads out quickly once they hit the ground. Downbursts involve high winds similar to a EF0 or EF1 tornado and heavy rains [5]. Derecho are a straight-line wind storm event that occur as part of a severe thunderstorm event and can involve high winds, heavy rains, and flash floods. The winds can be of similar strength to those found in tornadoes [6]. A warmer climate may increase the “fuel” for thunderstorms, leading to more frequent favourable conditions for downbursts and derechos.

Hurricane/Typhoon

The wind speed and rainfall associated with tropical cyclones are projected to increase as a result of climate change. In a 2°C warmer world, it is determined that the data below applies to the time horizon 2051-2080 for the RCP4.5 emission scenario while it represents the climate for the 2021-2050 periods in the RCP8.5 scenario.

Hurricane/ Typhoon	Historical		2°C Warmer World	
	Wind speed (km/h)	Rainfall (mm)	Wind speed (km/h)	Rainfall (mm)
Tropical cyclones	51.8	51.1	52.3-57.0	56.2-58.8
Extra-tropical cyclones	66.1	46.6	66.7-72.7	51.3-53.6

Extra-Tropical Storms

Extra-tropical storms can form from extra-tropical cyclones (hurricanes) or cyclogenesis, which develop in connection with the jet stream. Extra-tropical cyclones are large rotating weather systems that occur in the extra-tropics; a tropical cyclone will often transform into an extra-tropical cyclone as it recurves poleward and to the east [7]. It is anticipated with a warming climate that the jet stream will shift further north in winter and could bring PWMF into the path of the jet stream and extra-tropical cyclones. There is no scientific consensus on the impact of climate change on the intensification of tropical cyclones and/or extratropical storms.

A.8.2 Assessment

These climate hazards are a combination of High Winds and/or Rainfall events. As such they are assessed with respect to these hazards and projections where available. Where no conclusive statements may be drawn, a qualitative assessment will be performed based on the possible connection between progressive warming and the occurrence of more severe thunderstorms, tornadoes, and extra-tropical storms.

A.9 Ice Storm/Freezing Rain/Sleet

A.9.1 Projections

Ice Storm/Freezing Rain/Sleet

Ice Strom, Freezing Rain, and Sleet were defined as the annual freezing rain hours averaged across each time period.

Annual Freezing Rain Hours (Hr)	Historical (1980-2009)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean	24	-	21	-	12

A.9.2 Assessment

There is not sufficient understanding of the impacts of climate change on freezing rain to form projections; however, the conditions for freezing rain may decrease with increasing ambient air temperature. The projections indicate a 50% decrease in annual freezing rain hours on a 40-yr timescale. As the severity of ice storm, freezing rain, and sleet is projected to decrease over the life of the facility there is unlikely to be a significant hazard to PWMF through interactions with this climate hazard under the effects of climate change.

A.10 Low Lake/River-level and Hydrological Drought

A.10.1 Projections

Low Lake/River-level and Hydrological Drought

The lowest annual lake levels and the probability of a dry period (with less than 0.1 mm of precipitation) of at least 10 days for the future time periods were determined.

Annual Lake Level	Historical (1981-2010)	10-yr Projections (2021-2050)		40-yr Projections (2051-2080)	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Lowest Annual Lake Level (m)	74.3	74.1	74.0	74.4	74.4
Probability of Dry Periods (%)	82	83	82	81	84

A.10.2 Assessment

While the probability of dry period of at least 10 days remains similar for both emissions scenarios, there is projected to be an increase in the probability of no precipitation for at least 14 days of 13.4% under a 2°C warming scenario. The historic low lake level is 74.3 m.