Appendix N

Climate Change Resilience Assessment

Climate Change Resilience Assessment of the Crawford Nickel Project

September 30, 2024

Prepared for:

Canada Nickel Company

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Executive Summary

Canada Nickel Company (Canada Nickel) proposes to develop, construct, operate, and progressively reclaim a new open pit nickel mine and processing facility, collectively known as the Crawford Nickel Project ('the Project'), approximately 42 km north of Timmins, Ontario. The Project includes the development of an open pit, ore, waste and overburden stockpiles, two ore processing plants, and other mine related infrastructure and facilities, as well as a new rail spur line and the relocation of Highway 655 and existing 500 kilovolt (kV) transmission line. Ore will be extracted from a single open pit that will be divided into an east zone and main zone. The Project has a mineral reserve estimate of 1,715 million tonnes (Mt) and an expected project life of 41 years.

Stantec Consulting Ltd. (Stantec) completed a Climate Change Resilience Assessment (CCRA) for the Project, as part of the requirements set out in the Tailored Impact Statement Guidelines: Crawford Nickel Project (Impact Assessment Agency of Canada [IAAC] 2023) (TIS Guidelines). The CCRA was completed in alignment with the Government of Canada's *Strategic Assessment of Climate Change: Assessing Climate Change Resilience* Draft Technical Guide (2022) and other risk management best practices, including ISO 31000:2018 Risk Management, ISO 14091:2021 Adaptation to Climate Change, and the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol.

The intent of the CCRA is to identify current and future climate-related risks to the Project assets, infrastructure, and operations, and develop climate adaptation and resilience measures that can be considered by Canada Nickel to reduce the physical impacts of climate change during the life of mine, including mine construction and development, ore extraction operations and processing, through to mine closure and post closure activities.

A total of 328 risks were identified across six consequence criteria - Functional, Structural, Operations and Maintenance, Health and Safety, Environmental and Financial. Risks were assessed across 10 climate hazards with the highest risks to the Project associated with wind gusts, extreme heat, heat waves, and long-duration rainfall.

Wind gusts are projected to be responsible for approximately 20% of total risks. Risks from are moderate in the 2020s and 2050s, becoming high in the 2080s.Wind gust risks are predominantly related to potential structural damage to modular and pre-engineered buildings, increases in fugitive dust, and health and safety hazards from wind-blown debris and dust.

Extreme heat and heat waves cumulatively comprise 26% of total risks and 37% of high risks by the 2080s. High risks occur in the 2020s, 2050s and 2080s, largely associated with impacts related to increased cooling demand on HVAC systems, potential transformer failures, increased fugitive dust and increased likelihood of heat-related illnesses.

Long duration rainfall and short duration high intensity rainfall cumulatively comprise 24% of the total risks. Short duration risks were low to negligible across all time periods. Moderate and high risks from long duration rainfall were associated with functional and environmental impacts related to water ponding in pits and roadways, erosion and potential overtopping of tailings management facility berms and dam, and overwhelming of dewatering systems.

Open pit infrastructure components, including access/haulage roads and berms, mining equipment, pit operations, dewatering system, and trolley assist system are exposed to the highest number of total risks (94 risks). Administrative/support buildings are exposed to the second-most risks (63 risks) related to plant offices, medical clinic and firehall, gatehouse, assay lab, water management system, and explosives storage facility. The tailings storage facility comprised the third-most risks (27 risks) associated with the containment dam, berms, liners, spillways, pumps, pipes, valves and controls.

Adaptation measures were developed for all moderate and high-risk project infrastructure-climate hazard interactions and are presented in Table 14 in the report. The adaptation measures provided are not exhaustive and should be used as a guide to develop further project site and infrastructure specific adaptations to reduce the risks caused by the identified climate hazards. In addition to the adaptation strategies provided, it should be noted that many risks can be efficiently and effectively addressed and reduced through operations and maintenance (O&M) policy considerations and the development of Standard Operating Procedures (SOPs). The suggested O&M policies and SOPs presented should be reviewed and revised on a regular basis over the Life of Mine (LOM), so they adequately address current and future impacts to Project assets and workers under a changing climate.

Critical assets like tailings management facilities should be actively monitored and inspected as required by the guiding principles in the Global Industry Standards on Tailings Management (GISTM, 2020). This CCRA provides important information about climate and the impacts of climate change, which supports the requirements outlined in Principle 2, Principle 3, and Principle 5 in the GISTM document. While this CCRA only identified a few high risks for the tailings management facility, the ongoing risks related to climate change and the increasing frequency of extreme weather events need to be actively managed along with other physical factors (e.g., hydrology, geology, free board) that could contribute to a possible failure.

Despite the large number of risks identified, the limited number of high risks (or conversely the large number of low and moderate risks) can be viewed as an indication the proposed assets and infrastructure are expected to be resilient to the impacts of extreme weather and climate change, under current and future climate conditions. Climate conditions in the future will depend on the concentration of greenhouse gases (GHGs) in the atmosphere. Across multiple iterations of Intergovernmental Panel on Climate Change (IPCC) assessments, various scenarios have been developed to estimate GHG trajectories (emissions- or concentrations-driven) into the future, with focus on anthropogenic emissions. While these GHG scenarios provide a range of plausible futures for anthropogenic emissions, the exact rate of change and eventual concentrations in year 2100 (and beyond) cannot be precisely predicted. As such, a large source of uncertainty in all future climate projections is based in the future trajectory of global GHG emissions as controlled by societal actions. It is recommended this CCRA be considered a living document that should be reviewed and updated on a regular basis (initially every five years) as additional climate information and data becomes available, and new climate projection models are developed and current models updated.

Acronyms and Abbreviations

CADC	Climate Adjusted Design Criteria
CCRA	Climate Change Resilience Assessment
ECCC	Environment and Climate Change Canada
GCM	Global Climate Model
GHG	Greenhouse Gas
GISTM	Global Industry Standards on Tailings Management
HVAC	Heating, Ventilation and Air Conditioning
IDF	Intensity, Duration and Frequency
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LOM	Life of Mine
O&M	Operations and Maintenance
NOAA	National Oceanic and Atmospheric Administration
NRCAN	Natural Resources Canada
PCIC	Pacific Climate Impacts Consortium
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PMP	Probable Maximum Precipitation
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SOP	Standard Operating Procedure
SSP	Shared Socioeconomic Pathway
TMF	Tailings Management Facility

UNEP	United Nations Environment Programme
WMO	World Meteorological Organization

Glossary

Adaptation	Adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. Actions/measures that reduce the negative impacts of climate change, while taking advantage of potential new opportunities.
Adaptive Capacity	The IPCC defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate damages, to take advantage of opportunities, or to cope with the consequences.
Climate	The average, or expected weather and related atmospheric, land, and marine conditions for a particular location. In statistical terms, it is the mean and variability of relevant measures over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.
Climate Change	A persistent, long-term change in the state of the climate, measured by changes in the mean state and/or its variability. Climate change may be due to natural internal processes, natural external forcings such as volcanic eruptions and modulations of the solar cycle, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Climate Change Resilience	The ability of a system (built, natural, social or economic) to anticipate, withstand, recover, adapt to and transform in response to a climate-related hazard.
Climate Hazard	The potential occurrence of a natural or human-induced physical event or trend, or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources. In this report, the term hazard refers to climate-related physical events or trends or their physical impacts.

Climate Impact	The effects on natural and human systems of extreme weather, climate events and climate change. Impacts generally refer to effects on lives, livelihoods, health status, ecosystems, economic, social, and cultural assets, services (including environmental), and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.
Climate Model	A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.
Climate Projection	An estimate of longer-term future climate.
Confidence	The validity of a result is based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement across multiple lines of evidence. Confidence is expressed qualitatively. Five qualifiers are used to express assessed levels of confidence in findings (very low, low, medium, high, and very high) in IPCC (2013) and in Canada's Changing Climate Report (Bush and Lemmen, 2019).
Consequence Score	A rating (0 to 5) used to define the severity of the consequences of a climate hazard or weather event impacting a particular infrastructure component.
Consequence Criteria	A consequence in the context of the CCRA is defined as a measure of the impact to an asset or infrastructure component caused by a climate hazard. Consequence criteria (e.g., Functional, Structural, Operations and Maintenance, Health and Safety, Environmental, and Financial) are selected to capture the types of impacts the selected climate hazard will have on the assets and infrastructure and to define the types of risks caused by the interaction.
Design Life	The period during which the infrastructure is expected to operate within design parameters. Notionally, the length of time between commissioning and the onset of wear-out. Typically, design life is a shorter duration than the period between commissioning and the anticipated time of actual

	failure. In some cases, design life is stated in terms of the economic return period of an engineering project. The design life of the infrastructure, as a whole, may be different than the individual components that comprise the infrastructure based on routine refurbishment or replacement of components over the useful life of the infrastructure.
Global Climate Model (GCM)	Complex computer simulation of the climate system usually including interacting simulations of the atmosphere, ocean, ice, and land surface. The climate system can be represented by models of varying complexity. Climate models are developed and used at climate research institutions around the world to make projections of future climate, based on future scenarios of greenhouse gas and aerosol forcing.
Infrastructure Component	One of several physical features, processes, procedures and/or human resources that comprise the infrastructure.
Infrastructure Response	The generally anticipated effects arising from the climate and other change parameters interacting with the infrastructure components.
Infrastructure Threshold Value	A value representing an infrastructure specific weather event or climate trend that triggers an undesirable infrastructure response.
Interaction	The interface between weather events and/or climate trends and infrastructure components.
Life Cycle Analysis (LCA)	The whole-life approach from resource extraction through manufacturing, transportation, installation, use, maintenance and disposal or recycling which provides the critical long-term information necessary to make evidence-based, sustainable design and manufacturing decisions.
Likelihood (in quantifying climate change uncertainty)	The chance of a specific outcome occurring, where this might be estimated probabilistically. The likelihood of a result occurring is based on quantified measures of uncertainty expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment). Likelihood is expressed quantitatively.
Likelihood (in risk analysis)	The chance of an event or an incident happening (i.e., a climate related hazard), whether defined, measured or determined by qualitative or quantitative means.

Net Zero Carbon Ready Building	A net-zero carbon ready building is one in which energy consumption is reduced to a minimum through building design strategies and efficiency measures to the point where it would be practical/economical in the future to use non-carbon based (fossil) fuel sources to meet its energy needs.
Professional Judgment	The application of training, knowledge, experience, and skills gained over a prolonged period of professional practice.
Regional Climate Model (RCM)	Regional climate models (RCMs) provide climate projections on a smaller grid scale than GCMs. They are based on GCMs to initiate the model process then produce parameters on the smaller scale using a process called dynamic downscaling.
Representative Concentration Pathway (RCP)	Scenario of future greenhouse gas concentrations, and other anthropogenic forcings, based on various possible levels of human emissions. Representative Concentration Pathways (RCPs) are identified by a number indicating the change in radiative forcing by the end of the 21st century. RCP 2.6 represents a low emission pathway with a radiative forcing of roughly 2.6 W/m2, RCP 4.5 and RCP 6 represent intermediate emission pathways, and RCP 8.5 represents a pathway with continued growth in greenhouse gas emissions, leading to a radiative forcing of roughly 8.5 W/m2 at the end of the century. The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome.
Resiliency	Resiliency is the elasticity, or adaptability of buildings to ‘endure’ and maintain operations in changed climate conditions or recover from a climate change related disruption or impact. It requires designers to identify hazards and vulnerabilities local to a given site, before projecting impacts and implementing measures that reduce risk and increase flexibility to adapt.
Risk Assessment	The overall process of risk identification, risk analysis and risk evaluation.
Scenario (forcing scenario, emission scenario)	A plausible representation of the future based on a coherent and internally consistent set of assumptions. A forcing scenario is a possible future evolution of greenhouse gas concentrations and other anthropogenic forcings. An emission scenario describes a possible future

	evolution of emissions of greenhouse gases, and other climate drivers. They assist in climate change analysis, including climate modelling and the assessment of impacts, adaptation, and mitigation. The likelihood of any single emissions path described in a scenario is highly uncertain.
Shared Socio-economic Pathway (SSP)	Shared Socio-economic Pathways (SSPs) describe alternative socio-economic futures in the absence of climate policy intervention, comprising sustainable development (SSP1), regional rivalry (SSP3), inequality (SSP4), fossil-fueled development (SSP5) and middle-of-the-road development (SSP2). The combination of SSP-based socio-economic scenarios and Representative Concentration Pathway (RCP)-based climate projections provides an integrative frame for climate impact and policy analysis (IPCC 2018)
Shock Event	An acute natural or human-made event or phenomenon threatening major loss of life, damage to assets and a building or community's ability to function and provide basic services, particularly for poor or vulnerable populations. Examples include heat waves, extreme storms and storm surge.
Smart Building	"Smart Building" design for a Building Automation System (BAS) is an advanced control system that collects raw data from equipment/instruments and continuously analyzes the data to optimize the building environment and HVAC system efficiency.
Stress Event	An ongoing or cyclical natural or human-made event or phenomenon that renders an organization, asset/infrastructure, or community less able to function and provide basic services. Examples include prolonged droughts, increasing temperatures, and rising sea levels.
Vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of changing climate, including climate variability and extreme weather.
Weather	The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity, and barometric pressure.

Zero Carbon Building	A Zero Carbon building is one in which there is no fossil fuel use onsite for daily operations except for backup generators and systems. Any onsite energy used should be low carbon (e.g., clean electricity, renewable natural gas or approved forms and sources of biomass). Residual GHG emissions from the use of very low carbon electricity grids do not need to be included.

1 Introduction

The impacts of climate change and extreme weather can potentially impact a mine at any stage of a project's life cycle, from prefeasibility and feasibility studies through exploration and resource development, to mining and operations to mine closure and post closure. Future climate conditions should be considered at each stage of the mine life cycle, to avoid unexpected consequences by reducing climate-related risks and developing climate resilient mine assets and infrastructure.

In addition to climate impacts, mining operations are vulnerable to a variety of external influences over the extended life of these assets, including fluctuating commodity prices, labour availability and changing local labour laws, work and environmental regulations, equipment costs and supply change disruptions. Climate change has the potential to affect Project site conditions on a broad scale, impacting resource development and extraction schedules, construction timelines, water management, and tailings storage, impacting mining operations and revenues, and in extreme cases, potentially causing long-term operational delays and possible mine closures.

With the growing global awareness and documented impacts of climate change on corporate assets and operations, climate change considerations and the management of climate change-related risk and associated liabilities are increasingly becoming a requirement of many public companies. There is a growing expectation from investors, lenders, insurers, and Indigenous Nations and the general public for companies to provide guidance on how they are assessing the physical risks and opportunities posed by climate change, and how the potential operational, regulatory, financial, and reputational impacts related to climate change are being managed. The effects of climate change-related risks to a mine's operations and assets need to be assessed and the potential impacts on the company's income and balance sheets evaluated and disclosed as part of a company's Environmental and Social Governance (ESG) requirements.

Stantec was retained by Canada Nickel to complete a Climate Change Resilience Assessment (CCRA) for the Project. The report has been prepared to inform the Impact Statement, pursuant to the *Impact Assessment Act*, *2019* and in consideration of the Tailored Impact Statement (TIS) Guidelines: Crawford Nickel Project (IAAC, 2023). The intent of the CCRA is to identify current and future climate-related risks to Project assets, infrastructure, and operations, and develop climate adaptation and resilience measures that can be considered by Canada Nickel to reduce the physical impacts of climate change during the Life of Mine (LOM), including mine construction and development, operations, closure and post closure monitoring and maintenance.

The results of the CCRA will be used to assess how the Project will be able to withstand potential impacts from climate hazards and extreme weather in accordance with the requirements of the TIS Guidelines for the Project (IAAC, 2023). The CCRA can be used to provide guidance on how to build and operate the Project to be resilient to climate change and extreme weather over the mine's operating life cycle.

1.1 Project Overview

Canada Nickel proposes to develop, construct, operate, and progressively reclaim the Project located 42 kilometres (km) north of Timmins, Ontario. The Project includes the development of an open pit, stockpiles, two ore processing plants, and other mine-related infrastructure and facilities, as well as a new rail spur line and the relocation of Highway 655 and an existing 500 kilovolt (kV) transmission line (Figure A.1, Appendix A). Ore will be extracted from a single open pit that will be divided into an east zone and main zone. The Project has a mineral reserve estimate of 1,715 million tonnes (Mt) and an expected project life of 41 years.

1.2 Climate Change Resilience Assessment Methodology

Stantec's Climate Change Resilience Assessment (CCRA) methodology supports the requirements of the Technical Guide Related to the Strategic Assessment of Climate Change (ECCC, 2022) and uses a similar assessment approach as the Institute for Catastrophic Loss Reduction Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol (ICLR 2024) and Infrastructure Canada's Climate Lens General Guidance (Climate Lens, 2024). The methodology also aligns with the following international standards:

- ISO 31000:2018 – Risk Management – Principles and Guidelines
- ISO 14090:2019 – Adaptation to Climate Change — Principles, Requirements and Guidelines
- ISO 14091:2021 – Adaptation to Climate Change — Guidelines on Vulnerability, Impacts and Risk Assessment.

This CCRA identifies and assesses how the Project infrastructure and operations will respond when exposed to selected climate hazards and extreme weather events, under current and future climate conditions over the LOM. The general climate risk process follows the six steps illustrated on Figure A.2 (Appendix A).

A scan of regional and site-specific climate change conditions was completed to determine the climate hazards that Project assets and infrastructure might be exposed to over the LOM. Historical climate data collected from available weather stations in the Project vicinity was used to establish the climate baseline. Future climate projections using Global Climate Models (GCMs) for the 2020s, 2050s, and 2080s (to align with the LOM, including closure and post closure monitoring requirements) were used to determine the future likelihood of occurrence of the climate hazards.

The mine plan and site layouts were reviewed and used to assemble a list of built and natural assets and related infrastructure components to be considered as part of the CCRA. Each asset was reviewed, and climate hazard-asset exposures and potential impacts were determined. Using the impacts as a guide, consequence scores were assigned for each climate hazard-asset/infrastructure component exposure. Using the likelihood of the climate hazard and the consequence score assigned to the interaction, the climate risk to each asset was determined for the baseline (1981-2010), 2020, 2050 and 2080 time periods (see Section 1.3 for more information about time scales). For all medium, high, and extreme risks, climate adaptation and mitigation measures were identified.

The impacts of the climate exposure on Project assets and infrastructure are assessed under six consequence categories (Structural, Functional, Operations and Maintenance, Health and Safety, Environmental and Financial), which were selected to align with Canada Nickel's Risk Registry. The climate hazards selected are specific to the location of the infrastructure being assessed and can include chronic (gradual or repeated onset – e.g., gradual warming) or acute (rapid occurrence - e.g., extreme temperatures, intense precipitation, and high wind events) changes in climate conditions and/or extreme weather events. The general process used for this CCRA is illustrated on Figure A.3 (Appendix A). A climate profile for the Project has been prepared and is included in Appendix B for reference.

1.3 Timescale of Assessment

To cover the climate risks associated with the LOM of the Project, the following time horizons have been selected for the CCRA (See Table 1).

- Baseline climate includes the period from 1981-2010, which provides the most complete data for the Project Area (PA). Historical data from weather stations in the vicinity of the Project were used to determine the climate baseline for the CCRA.
- Short-term projections include the period 2011-2040. Referred as the 2020s, short-term projections help inform climate risks during the construction and operations phases.
- Mid-century projections include the period from 2041-2070. Referred to as the 2050s, they help inform an understanding of the climate trends and emergent and potentially increasing urgency for adaptation and risk mitigation measures during the remaining period of mining and onset of decommissioning, mine closure and asset transformation.
- End-of-century projections from 2071-2100, referred to as the 2080s, allow for longer term, forward planning activities related to emergent risks and the urgency of design adaptation and risk mitigation relating to post-closure monitoring and maintenance, and any asset transformation plans considered for the Project.

Table 1 Time Horizons for Assessment

Time Horizons		Rationale for Selection
Baseline	1981-2010	Climate baseline
2020s	2011-2040	Mine development and active mine operations
2050s	2041-2070	Open Pit Mining completed; Ore processing continues. Extended Life of Mine – mine closure/decommissioning, closure and post closure monitoring, asset transformation (optional)
2080s	2071-2100	Mine closure and post-closure / asset transformation - maintenance and monitoring

1.4 Assumptions and Limitations

This CCRA was completed using the information available at the time of the assessment. The assessment represents the climate risks associated with baseline climate (1981-2010) and future climate for the 2020s (2011-2040), 2050s (2041-2070), and 2080s (2071-2100). The climate data and trends (current and future projections) used in this study were obtained through various sources. Cross-verification between climate information sources was conducted where possible to identify potential discrepancies between the data sources used.

The analysis and recommendations of this CCRA are based on the information available within the time frame and scope of this assessment, and on the authors' experience in CCRAs. The climate risk methodology used is consistent with ISO 31000: Risk Management and ISO 14090/14091: Adaptation to Climate Change standards.

The frequency of occurrence of the selected climate hazards (as defined by the intensity thresholds selected) for current climate are based on observational data from Environment and Climate Change Canada (ECCC) weather stations. Data availability of ECCC weather stations was also considered in the analysis. It is recognized that extreme weather events are often very localized, so it is possible that local weather stations may not measure some of these climate events.

Future climate projections used in this CCRA are based on the Sixth Coupled Model Intercomparison Project (CMIP6) climate projections data. There are nearly 35 GCMs that have contributed to CMIP6, which forms the basis of the Sixth Assessment Report and other recent publications from the Intergovernmental Panel on Climate Change (IPCC). The climate projections for this assessment were based on the statistically downscaled datasets from 26 GCMs of the CMIP6 and Regional Climate Models (RCMs) datasets from various sources. The climate projections used for this CRRA are based on the CanDCS-U6 climate projections data for the SSP2-4.5 and SSP5-8.5 emissions scenarios. Additional details of climate projection data used for this Project are presented in Section 3.1.

Climate hazards can cause situational/location impacts outside the Project property boundary. Offsite climate related events including services provided by third parties (i.e., telecom, power) can have substantial impacts to the assessed infrastructure. The spatial boundary limits for this CCRA focuses on the Project assets and infrastructure components. Due to this, the assessment may not have fully assessed the risks associated with cascading climate events occurring outside of the immediate Project area, as this work is considered out of scope for the current CCRA.

2 Project Infrastructure

The major Project assets and facilities assessed under the CCRA are shown in Table 2.

Table 2 Crawford Nickel Project Assets and Infrastructure List

Asset	Asset Category	Asset/Infrastructure Components
Buildings	Administrative and Support Buildings (Modular)	Offices
		Medical Clinic and Firehall
		Gatehouse
		Assay Lab
		Explosives Storage Facility
	Mine Infrastructure Buildings (Pre-engineered)	Maintenance Buildings/ Workshops/Garages
		Warehouse
	Process Plant Buildings (Pre-engineered)	Primary/Secondary Crushing and Crushed Ore Stockpile Covers (Geodesic Dome)
		Conveyors and Crushed Ore Tunnel
		Process Plant Building
		Thickener
		Concentrate Loadout Buildings
Open Pit, Ore and Waste Storage	Open Pit	Access/Haulage Roads/Berms
		Mining Equipment (trucks/shovels/mine fleet machinery)
		Pit Operations (blasting/hauling/surveying)
		Dewatering System and Equipment
		Trolley Assist System
	Ore/Waste Stockpiles	Rock, Sand, Till and Clay Stockpiles and Impoundments
		West and East Stockpiles, Overburden Stockpiles
Tailings Management Facility (TMF)	TMF Storage Area	Containment Dam/Berms, Liner, Spillways
	TMF Tailings Transport and Management	Pumps/Pipes/Valves/Controls and Monitoring
Site Services	Site Power	Electrical Substations
		Power Distributions
		Standby/Emergency Power Supply
	Fuel Farm	Diesel, Gasoline and Diesel Exhaust Fluid Storage Tanks

Asset	Asset Category	Asset/Infrastructure Components
Site Services	Potable Water	Potable Water Treatment Plant and Storage Tank.
	Service Water	Piping, Pumps, Water Source and Treatment
	Wastewater	Wastewater Treatment Plants
	Site Water Management	Drainage Ditches, Ponds
	Roadways	Access Roads and Site Roads
Third Party Services	Power Supply	High-voltage Powerlines, Poles/Towers, Transformers, Substations

3 Climate Hazards Assessment

Climate profiles are important tools used to illustrate climate trends occurring in recent history (i.e., over the last 30 years or longer) and projected future climate conditions to help inform design and/or adaptation actions. Historical climate records, usually in the form of meteorological data measured at weather stations, are used to describe the historical climate trends for an area. ECCC provides the largest database of observational historical weather and climate data in Canada.

Future climate projections are determined using GCMs. Climate projections are descriptions of plausible future climate, based on assumptions about future economic, social, technological, and environmental conditions, which will drive greenhouse gas concentrations in the atmosphere. Climate models are the primary tools used to develop three-dimensional climate projections. Since 1995, the Coupled Model Intercomparison Project (CMIP) has coordinated the international design and distribution of GCM simulations of past, present, and future climate (WCRP, 2024). Most recently, GCMs have contributed to CMIP Phase 6 (Eyring et al., 2016), which forms the basis of the Intergovernmental Panel on Climate Change (IPCC) *Sixth Assessment Report* (IPCC 2021).

All climate models have inherent shortcomings in fully and accurately representing the real climate system. Therefore, it is not recommended to rely only on one or two GCMs to estimate future climate. Instead, an average of several GCMs (a multi-model mean) tends to give a more reliable estimate of future climate (IPCC 2013, 2021). The use of ensembles and multi-model means is common in climate science and is strongly encouraged as “best practice” (IPCC 2013, 2021). Using ensembles and multi-model means provide insight into uncertainties in climate model projections. Therefore, the ensemble means of the 26 CMIP6 GCMs is presented in this assessment.

In addition to the CanDCS-U6 projections, specialized studies are also used in the assessment. Specialized research can provide additional insight into combined or complex climate variables, such as high wind gusts, wildfire weather, and permafrost thaw. This assessment also incorporates the CSA Group’s Rainfall Intensity-Duration-Frequency Guide (CSA PLUS 4013:19) recommendation to use the Clausius-Clapeyron relation method for estimating projected changes to short duration, high intensity precipitation events.[1]

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[1] The Clausius-Clapeyron relation is founded on the atmospheric physics theoretical relationship between air temperature and the holding capacity of the atmosphere (i.e., the amount of water the air could potentially contain). The Clausius-Clapeyron relation indicates that there is, on average, a 7% increase in the air’s holding capacity per 1°C of local warming.

3.1 Climate Projections and GHG Scenario Selection

There are approximately 35 GCMs that have contributed to the Sixth Coupled Model Intercomparison Project (CMIP6[2]), which forms the basis of the *Sixth Assessment Report* from the IPCC.[3] CMIP6 global climate models represent the most up to date climate modelling and representations of physical, chemical, and biological processes are based on Shared Socioeconomic Pathways (SSPs). The Canadian Downscaled Climate Scenario – Univariate (CMIP6) (CanDCS-U6) has taken a subset of 26 of these models to produce reliable, high-resolution downscaled climate projections for Canada (Statistics Canada 2021). The high-resolution Pacific Climate Impacts Consortium (PCIC) downscaled projections are a primary source for climate change assessment in Canada and are the official climate change projection dataset of Environment and Climate Change Canada (ECCC).

In addition to the physics of the GCMs, global progress towards meeting greenhouse gas (GHG) emissions targets is also a large source of uncertainty in future climate projections. Climate modeling uses various GHG emissions scenarios to project future climate variables under different concentrations and rates of release of GHGs to the atmosphere. Various future trajectories of GHG emissions are possible depending on the global mitigation efforts in the coming years and decades. For this Project, scenarios from the IPCC Sixth Assessment Report (AR6) were carried forward for assessment.

Five GHG emissions scenarios with associated socio-economic development patterns were set forward by the IPCC as shown on Figure A.4 (Appendix A). This CCRA assesses climate risk using two shared socio-economic pathways (SSPs), SSP- 8.5 and SSP2-4.5, to determine how climate risks to the Project may change depending on the global socio-economic response to reducing greenhouse gas emissions. Where CMIP6 data is not available, select studies using CMIP5 climate projections have been used in this assessment. **SSP2-4.5** is described as the middle of the road scenario and assumes world social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, and progress by global and national institutions work toward achieving their sustainability goals (e.g., UN Sustainability Goals) is slow. Under the SSP2-4.5 scenario, environmental systems experience degradation, the intensity of resource and energy use declines, and global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain. SSP2-4.5 is based on historical patterns of development continuing throughout the 21st century, which will result in a stabilization and some reduction on greenhouse gas emissions.

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[2] CMIP6 is the 6th Phase of the Coupled Model Intercomparison Project (CMIP), which forms the basis of the IPCC *Sixth Assessment Report* (IPCC, 2021). CMIP coordinates the international design and distribution of global climate model simulations of past, present, and future climate.

[3] IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

SSP5-8.5 assumes there are high challenges to mitigation and low challenges for climate adaptation (Global Change Data Lab, ND). Competitive markets, innovation and participatory societies produce rapid technological progress and development of human capital as the path to sustainable development. Strong investments in health, education, and institutions to enhance human and social capital coupled with increased economic and social development and the adoption of resource and energy intensive lifestyles around the world, results in the exploitation of abundant fossil fuel resources. SSP5-8.5 assumes global growth will be driven by an energy-intensive, fossil fuel-based economy, with increasing GHG emissions resulting in average global temperature increase exceeding the Paris Accord target of 1.5°C.

Although some progress has been made, current estimates of GHG emissions are still close to following the SSP5-8.5 trajectory. Therefore, this CCRA will focus on the GHG socioeconomic pathway scenario SSP5-8.5.

3.1.1 Confidence Levels in Climate Projections

Some climate variables can be projected into the future with more confidence than others. The level of confidence in climate projections is dependent on the understanding of the processes involved in the climate phenomena, ability of climate models to simulate the phenomena, degree of agreement among the climate models (e.g., range of uncertainty), and the supporting evidence (e.g., theory, specialized literature, expert judgment). Projections based on GCMs and downscaling of such models are considered to have high confidence for general temperature and precipitation projections, moderate confidence for extreme parameters, and low confidence for combined or complex events.

Combined or complex climate variables are normally inferred from other climate variables and result in lower confidence for projections. For example, freezing rain is a complex process and the projected prevalence of freezing rain events under future climate conditions is not as well understood as other variables. Confidence may also refer to whether other specialized studies have been done for the climate events projections in the geographical area.

The confidence levels used for the climate projections in this CCRA are described in Table 3. A 3-level standard scale of low, moderate, and high has been applied, but depending on the climate parameter, intermediate levels (e.g., “low to moderate”) may be used to define the confidence in the climate data (Cannon et al., 2020).

Table 3 Confidence Levels in Climate Projections

Confidence Level in Climate Projections	Description
High	High level of confidence in projected changes of the climate variable based on an in-depth knowledge of the processes involved with the climate phenomenon and a broad body of evidence, including on a local or regional level. Relevant data are available in large quantities and are of high quality. Projections and studies are very consistent and relevant.

Confidence Level in Climate Projections	Description
Moderate	Moderate level of confidence in projected changes of the climate variable based on considerable knowledge of the process involved with the climate phenomenon and a body of evidence on a regional or larger scale. Relevant data are available and of good quality. Projections and studies are consistent and relevant. Level of confidence attributed is justified by literature.
Low	Low level of confidence in projected changes of the climate variable based on a limited body of knowledge about the climate phenomenon and limited body of evidence (phenomenon has not been widely studied in published literature). There is some relevant data of quality and lower level of consistency among specialized studies. Further study necessary to increase confidence level in projected changes.

Despite low levels of confidence in some climate projection values, the general projected trend in frequency can provide valuable information for planning purposes (e.g., adaptation strategies). For climate parameters with low confidence levels in the projections, additional studies (e.g., sensitivity analyses) can provide further insight into the potential impacts of climate change on infrastructure reliability in different warming and load combination scenarios. Variability of future climate change projections and confidence level of the climate data are considered in the CCRA methodology when determining the likelihood ratings for the climate hazards for this CCRA.

3.2 Climate Profile for Crawford Nickel Project Area

The historical climate for the PA is based on data from ECCC weather stations in the City of Timmins as shown on Figure A.5 (Appendix A). Although Timmins is about 42 km away from the Project site, the weather station data can serve as a climate proxy due to the availability of historical climate data. Data from the four ECCC weather stations for Timmins range from hourly to monthly time steps. Some of them have the same station name but cover different time ranges, others have less than 30 years of record.

A summary of the weather stations with historical datasets is shown in Table 4. The four ECCC stations were merged to obtain the complete datasets of temperature, precipitation, snow and wind, which results in a climate record for the Timmins region for the periods from 1981-2010 and 1991-2020. For all missing temperature and precipitation data between 1950-2010, the NRCan-met gridded dataset was used to fill in the data gaps.

Table 4 Summary of weather monitoring stations in the Timmins Region

Weather Monitoring Station	Latitude	Longitude	Station ID	Data Range (Daily) [% of Data Available]	Elevation	Approximate Distance to Project site
Timmins	48°30’00.000 N	81°20’00.000 W	ECCC (6078280) [Daily]	1950-1957 [Temperature 94.5% Precipitation 81.2% Wind 0.0% Snow 82.0%]	335.3 m	~36.42 km
Timmins A	48°34’14.000 N	81°22’36.000 W	ECCC (6078286) [Daily and Hourly]	2012-2024 [Temperature 98.4% Precipitation 17.9% Wind 84.5% Snow 19.6%]	294.7 m	~28.70 km
Timmins Victor Power A	48°34’11.000 N	81°22’36.000 W	ECCC (6078285) [Daily and Hourly]	1955-2012 [Temperature 99.2% Precipitation 94.6% Wind 97.5% Snow 94.6%]	294.7 m	~28.79 km
Timmins Climate	48°33’26.000 N	81°23’25.000 W	ECCC (6078282) [Daily and Hourly]	2008-2024 [Temperature 96.3% Precipitation 95.2% Wind 83.1% Snow 0.0%]	294.4 m	~30.28 km

The regional climate of Timmins is defined as humid-continental climate, which is typically characterized by a warm and humid summer and a cold winter with precipitation spread throughout the year. The climate hazards related to extreme temperatures (heat and cold), rainfall, freezing rain, heavy snowfall, droughts, lightning strikes, wildfires, temperature inversions and high wind speeds are identified as growing climate concerns for the built infrastructure in the region.

A summary of climate trends and projections for the Timmins region is presented below. Detailed historical climate data and future climate projections (including charts and graphs displaying the data) for the region are presented in the climate profile in Appendix B.

- The region has experienced (and is projected to continue experiencing) temperature increases for annual mean daily temperature, annual mean daily minimum temperature, and annual maximum daily temperature. This trend applies to all seasons. By the 2080s, the average annual maximum daily temperature is projected to increase by 3.9°C and 6.5°C under SSP2-4.5 and SSP5-8.5, respectively.
- The number of extreme heat temperature events (i.e., days with temperatures equal to or greater than 30°C) has averaged around 7.5 days/year for the 1981 to 2010 period. By the 2080s, the number of days over 30°C is projected to increase to 31.9 and 55.7 days/year under SSP2-4.5 and SSP5-8.5, respectively. This change is also expected to increase the frequency of heat waves (based on a 30°C threshold), which can translate into an increase in operation and maintenance costs and increased potential for heat related illnesses for workers on the Project.
- The number of cold temperature days (i.e., days equal to or below -30°C) is expected to decline from 15.5 days/year (1981-2010) to 2.6 and 0.4 days/year by 2080 under SSP2-4.5 and SSP5-8.5, respectively. This will also translate to an expected decline in the number of heating degree days (based on an 18°C threshold), which will result in a decrease in heating needs in the region.
- Total annual precipitation in the region is projected to increase by 10.8% and 18.3% under SSP2-4.5 and SSP5-8.5, respectively, for the 2080s from the 1981-2010 baseline. Seasonal precipitation (winter, spring and fall) is projected to increase in the region with the largest percentage changes (+22.5% [SSP2-4.5], +37.2% [SSP5-8.5]) in winter, while the summer precipitation is projected to remain relatively constant (+0.4% [SSP2-4.5], +0.1% [SSP5-8.5]) to the 2080s.
- Precipitation events are projected to become 31.6% and 58.9% more intense by 2080s under SSP2-4.5 and SSP5-8.5, respectively, for all design storms ranging from 5 minutes to 24-hour duration and 2 to 100-year return frequency, when compared to historical Intensity-Duration-Frequency (IDF) curves. This translates to increased potential for localized and overland flooding due to rapid and long-term accumulations with the potential to overwhelm stormwater and drainage management systems.
- Heavy snow events (i.e., with snowfall greater than 25 cm) are expected to remain at a similar level at 0.4 events/year due to cold air outbreaks and storm tracks. However, the type of winter precipitation is expected to change under a warming climate, as snowfall in this region is more

likely to occur than rain in a warming climate. This will likely translate into an increase in the percentage of mixed precipitation in the future.

- The number of freeze thaw cycles (days with a maximum temperature >1°C and minimum temperature <0°C) is expected to decrease from 78.9 days/year in the baseline climate to 62.1 and 59.9 days/year by the 2080s under SSP2-4.5 and SSP5-8.5, respectively. With warmer temperatures projected for the coming decades, the annual number of freeze-thaw events for the region is projected to decrease under the effects of climate change.
- The effects of climate change with respect to wind are not as well understood as other variables such as temperature. The percentage increases in future daily wind gust events of ≥90 km/h and 110 km/h from the current baseline condition could be 10% to 20% in most of the regions across Canada (Cheng et al., 2014). A similar trend for winds is expected under future climate for the Timmins region.
- Under a warming climate, research has shown that projected temperature changes may increase the likelihood of freezing rain events by the 2050s and 2080s. Freezing rain events in winter months (December, January, and February) could increase by about 40 to 100% in frequency of occurrence in the Timmins area for the 2050s and 2080s. For the warmer months (November, March, and April), future freezing rain events are projected to increase in frequency up to 10 to 40% (Cheng, 2011). However, other studies, using different freezing rain simulation methods and GCM ensembles have suggested that total annual freezing rain hours may decrease under warming temperatures while extreme events remain possible (McCray, 2022). Therefore, it is difficult to determine how freezing rain events will impact the Timmins region in the future due to limited supporting data and high uncertainty.

3.3 Identification and Assessment of Climate Hazards

The climate hazards selected for the CCRA are presented in Table 5. In addition, the rationale for selecting each climate hazard and the projected trend in frequency of (increasing, decreasing, or steady) over the time horizons studied is provided for reference.

Climate hazards are categorized as “acute” and “chronic” hazards, as defined below.

Acute hazards are those that impact infrastructure components over a relatively short period (e.g., hours to days). Acute climate hazards are specific weather events such as short duration high intensity rainfall and heavy snowstorms. It should be noted, extreme heat and heat waves, which are often acute events in many parts of the country, are starting to be assessed as chronic hazards due to the increasing frequency of occurrence.

Chronic hazards refer to longer-term, incremental shifts in climate patterns, such as changing annual average rainfall or temperature. Chronic hazards, because of their frequency in occurrence over long periods of time, gradually impact infrastructure components (e.g., years to decades). In most cases, chronic hazards are already occurring at the Project site, but it is important to consider how these events will change in the future because they can have substantive cumulative impacts on assets over the LOM.

A threshold value is determined for each climate hazard, which is used to establish the likelihood that a particular climate hazard will occur (return period). The value is normally associated with a consequence or effect/impact on an infrastructure asset or component should the threshold be exceeded. A climate hazard threshold is also used to establish the likelihood that a particular climate hazard will occur (i.e., return period of climate hazard). The likelihood that a climate hazard has occurred or will occur is based on the historical climate data and future climate projections based on climate models. Threshold values were assigned for temperature, precipitation, and high wind climate hazards that can be assessed quantitatively.

Special case climate hazards selected for the CCRA represent hazards that involve a combination of multiple independent parameters and/or require complex conditions for development. As a result, the likelihood of special case hazards often cannot be assessed quantitatively with a sufficient degree of certainty. Qualitative analysis using professional judgment may be necessary where there is a lack of adequate information and resources available, and the confidence level of the data is too low to determine the likelihood of the hazard quantitatively (SACC 2022). Therefore, special case climate hazards and their possible impacts on Project assets and infrastructure are discussed qualitatively in the CCRA.

Table 5 Selected Climate Hazards for CCRA

Climate Parameter	Climate Hazard	Threshold	Chronic (C)/ Acute (A)	Trend	Rationale
Temperature	Extreme heat	Average change in number of days with maximum temperature ≥ 30°C from Baseline	C	Increasing	Reduced asset/infrastructure/equipment functionality due to higher operating temperatures. Potential stress on Project workers (health and safety), resulting in delays in operations activities. Extreme heat and heat waves and extreme cold may cause deterioration of material properties (e.g., cracking and fissuring) and may decrease the service life of components (e.g., envelope related infrastructure). Extreme heat and heat waves create increased demand on building cooling and air handling systems and affect the systems' ability to maintain building temperatures.
	Heat wave	Average change in number of heatwaves (maximum temperature ≥ 30°C for 3 or more consecutive days) from Baseline	A	Increasing	
	Extreme cold	Days with minimum temperature ≤ -30°C	C	Decreasing	Extreme cold can result in wintertime temperature inversions influencing operations activities. Extreme cold can freeze pipes and equipment causing operational and functional disruptions to operations.
	Annual freeze-thaw cycles	Occurrence of 30 freeze-thaw cycles per year	C	Decreasing	Freeze-thaw cycles create slip and fall risks and can cause physical damage to concrete structures and foundations (threshold of 30 annual freeze-thaw cycles is associated with the premature deterioration of concrete). Possible impacts (e.g., cracking, deterioration) on hardscape (e.g., concrete, access roads), resulting in increased maintenance requirements and costs.

Climate Parameter	Climate Hazard	Threshold	Chronic (C)/ Acute (A)	Trend	Rationale
Precipitation	Extreme rainfall–short duration high intensity	50 mm in 1 hour	A	Increasing	Potential for localized flooding and/or overwhelming of stormwater and drainage management systems. Potential for structural damage to road/transportation infrastructure components (increase potential for erosion or washouts). Can affect level of freeboard on collection ponds. Increased erosion of stockpiles and Impoundment facility. Saturated soils may increase potential for pit wall or TMF berm failures. Ponding of water can exceed the capacity of the storm drainage system resulting in localized flooding and possible release to the environment.
	Extreme rainfall–long duration	100 mm in 24 hours	A	Increasing	
	Heavy snow	>25 cm in 24 hours	C	Stable	Potential for increased maintenance requirements and costs (e.g., snow removal). Potential for health and safety hazards to Project workers (e.g., slip-and-fall, falling snow-poor visibility). Heavy snow may result in increased load on building roof structures. Heavy snow may impact the air handling systems by blocking air intakes.
Other	Drought	Standardized Precipitation Evapotranspiration Index (SPEI12) Value[4] < -1	C	Increasing	Drought can result in an increase in fugitive dust, and associated dust suppression requirements. Extreme drought has the potential to affect the availability of water.

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[4] SPEI (Vicente-Serrano et al., 2023) is index representative of moist (positive) or dry (negative) conditions and can be used to understand periods of prolonged drought or moist conditions when coupled with a duration. SPEI12 is representative of conditions over a rolling 12 month interval.

Climate Parameter	Climate Hazard	Threshold	Chronic (C)/ Acute (A)	Trend	Rationale
	Wind gusts	Wind gusts ≥ 90 km/hour	A	Stable	Potential for structural damages to buildings (e.g., building envelope), roof panels, conveyor operations. Potential for health and safety hazards to Project workers (e.g., flying debris, increased dust). Potential impacts on transmission lines resulting in power loss/interruptions at the Project site. Increase in fugitive dust, and dust suppression requirements. Increase erosion/loss of material off stockpiles (e.g., overburden, ore, sand, till and clay).
Special Case	Thunderstorms (Lightning)	Qualitatively Assessed			Potential for damage to electrical equipment from power surges related to lightning strikes. Health and safety risk for Project workers from lightning strikes and fugitive dusts from high winds. Disruption to operations and potential loss in production from thunderstorms.
	Wildfires	Qualitatively Assessed			Loss of infrastructure or reduced site access can impact operations and production. Access restrictions can also impact availability of staff. Smoke from wildfires can be a health and safety concern for workers and may impact operations.
	Inversions	Qualitatively Assessed			Inversions can trap pollutants (diesel/exhaust fumes, dust, other pollutants) inside in the open pit, creating a health and safety concern affecting operations and possible production losses. Reduced visibility associated with fog can result in increased health and safety risks affecting pit operations.

3.3.1 Likelihood Scores

The likelihood of each climate hazard is based on the expectation that the climate hazard will exceed the defined threshold above which the event is expected to affect/impact/damage the asset, infrastructure, and/or result in a change in the level of service provided. The likelihood for an acute climate hazard is defined as the expected recurrence period of a climate event as described in Table 6.

Table 6 Acute Climate Hazards Rating Table

Score	Qualitative Descriptor	Descriptor	Occurrence
1	Very Low	Not likely to occur within period	<1:50 year
2	Low	Likely to occur at least once every 30 to 50 years	1:30-50 year
3	Moderate	Likely to occur at least once every 10 to 30 years	1:10-30 year
4	High	Likely to occur at least once per decade	1:1-10 year
5	Very High	Likely to occur once or more annually	>1/year

Estimating the likelihood for chronic climate hazards uses the "middle-baseline" approach to translate chronic hazard frequency/intensity to a likelihood score, based on the relative changes compared to the baseline period. The parameters used to determine likelihoods for chronic climate hazards are shown in Table 7.

Table 7 Chronic Climate Hazards Rating Table

Score	Change in Event Frequency/Intensity Compared to Baseline Climate	Descriptor
1	50-100% reduction compared to baseline	Likely to occur much less frequently than baseline climate
2	10-50% reduction compared to baseline	Likely to occur slightly less frequently than baseline climate
3	Within +/-10% compared to baseline	Likely to occur about as frequently as in the baseline climate
4	10-50% increase compared to baseline	Likely to occur slightly more frequently than baseline climate
5	50-100% increase compared to baseline	Likely to occur much more frequently than baseline climate

3.4 Likelihoods for Climate Hazards

Using the likelihood scales described in Table 6 and Table 7, the likelihood scores for the selected acute and chronic climate hazards for baseline climate and future time periods are presented in Table 8. In addition, the projected trend in frequency of occurrence for each climate hazard (increasing, decreasing, or steady) over the time horizons and the confidence level in the likelihood are provided for reference. Complex or special case climate hazards where the likelihood of occurrence cannot be determined with an acceptable level of confidence were not assigned a numeric likelihood score. Special case hazards are identified in the table as being assessed qualitatively.

It should be noted that the frequency of occurrence of a hazard can change while the likelihood score may not. For example, a climate hazard may have a likelihood score of four for all four time horizons but with an increasing frequency of occurrence from 1-in-8 years in the baseline climate, to 1-in-7 years in the 2020s, to 1-in-5 years in the 2050s, to 1-in-2 years in the 2080s.

3.4.1 Qualitatively Assessed Climate Hazards

Qualitatively assessed climate hazards require reviewing a combination of multiple independent climate parameters and the complex conditions for their development. Because of the complex nature of these hazards, there is often insufficient information and data to determine a quantitative likelihood of occurrence of these events with confidence. The estimated occurrence of each qualitative climate hazard is discussed in the following sections.

3.4.1.1 Lightning

The Canadian Lightning Detection Network recorded 13,679 cloud to ground (CG) lightning flashes from 1999 to 2018 within 25 km of Timmins (Kochtubajda et al. 2020) and an annual average of 25.7 days with lightning within 25 km of Timmins (Government of Canada 2019). Under the impacts of climate change, a proxy model based on precipitation rates and air circulation in the atmosphere has estimated that for roughly every 1°C increase in global average air temperature, there is a 12% (±5%) increase in lightning frequency in North America due to higher moisture content in the atmosphere (Romps et al. 2014).

3.4.1.2 Wildfires

Using the Canadian Wildland Fire Information System (NRCan, 2017), 36 separate large (<200 ha) wildfires for the 1950-2020 period were observed within a 100 km radius of the Project site. Under the RCP8.5 climate change projections, the area burnt by wildfires is expected to increase gradually from 2020 to 2050 and exponentially from 2050 to 2100 (Balshi, et al. 2009). Due to the predicted warmer temperatures, change in precipitation, and intensification of drought events, fire occurrences caused by lightning are expected to increase by an estimated 24% by 2040 and by 90% by 2090 in Ontario based on fire weather and fuel moisture scenarios from GCM climate projections and the LEOPARDS protection analysis system (Wotton, Logan, & McAlpine 2005). Temperature shows a strong positive correlation with lightning, humidity, and fire season; therefore, warmer temperatures may result in longer fire seasons and more frequent and intense wildfires. However, this conclusion is subject to a moderate amount of uncertainty due to the complex nature of wildfires, fuel type, and possible future fire management adaptation plans.

Table 8 Likelihood of Occurrence for Selected Climate Hazards

Socio-economic Pathway			SSP2-4.5							SSP5-8.5						
Climate Hazards		Threshold	Likelihood Scores				Chronic (C) Acute(A)	Trend	Confidence Level	Likelihood Scores				Chronic (C) Acute(A)	Trend	Confidence Level
			Baseline	2020s	2050s	2080s				Baseline	2020s	2050s	2080s			
Temperature	Extreme Heat	Days with Tmax ≥30°C	3	5	5	5	C	↑	High	3	5	5	5	C	↑	High
	Heat Wave	Tmax ≥30°C for Three or More Consecutive Days	2	4	5	5	A	↑	High	2	4	5	5	A	↑	High
	Extreme Cold	Days with Tmin ≤ -30°C	3	1	1	1	C	↓	High	3	1	1	1	C	↓	High
	Freeze-thaw cycles	Occurrence of 30 Freeze-thaw Cycles Annually	3	2	2	2	C	↓	Moderate	3	2	2	2	C	↓	Moderate
Precipitation	Short Duration High Intensity Rainfall	50 mm Rain in 1 hr	1	1	1	2	A	↑	Moderate	1	1	2	2	A	↑	Moderate
	Long Duration Rainfall	100 mm Rain in 24 Hours	2	2	2	3	A	↑	Moderate	2	2	3	4	A	↑	Moderate
	Heavy Snow	25 cm Snow in 24 Hours	3	3	3	3	C	→	Moderate	3	3	3	3	C	→	Moderate
	Freezing Rain	10-15 mm of Ice Accumulation	3	3	3	3	C	→	Low	3	3	3	3	C	→	Low
Other	Wind Gusts	Wind Gusts ≥ 90 km/hr	4	4	4	4	A	→	Low	4	4	4	5	A	↑	Low
	Drought	SPEI12 < -1	3	Not Available	Not Available	Not Available	C		Low	3	3	4	5	C	↑	Low
Special Case	Lightning	Annual Lightning Flash Density	Qualitatively Discussed							Qualitatively Discussed						
	Wildfires	Number of Large Fires within 100km	Qualitatively Discussed							Qualitatively Discussed						
	Inversions		Qualitatively Discussed							Qualitatively Discussed						

3.4.1.3 Inversions

A study of long-term changes in extreme air pollution meteorology has shown a warming climate is expected to increase evapotranspiration, releasing more latent heat in the upper troposphere. Consequently, atmospheric stability is generally expected to increase with climate change, leading to more temperature inversions. Additionally, the trends in temperature inversion event frequencies over non-polar continental regions in the Northern Hemisphere show clear seasonal variation, with the strongest increase (+17.4%) in summer and little change in winter.

Weather generally occurs in the lowest part of the earth's atmosphere or troposphere, which can extend to heights of 16 km above the earth's surface. Air temperature in the troposphere typically decreases with elevation. In an inversion layer, the atmosphere warms as it increases in elevation. This often happens in areas of high pressure, where the air aloft dries out and warms up as it falls towards the ground. The layer of warm air can act as a barrier to air movement, trapping cooler (and denser) air near the surface, creating an inversion.

Surface temperature inversions can have a substantial impact on air quality, especially during winter when the inversions have the strongest effects. This phenomenon can severely restrict the vertical movement of trapped air particles. Cooling frequently occurs in low places such as valleys and open pit mines, where they are sheltered from winds. Pollutants from mining equipment and blasting operations can be trapped near the surface of open pits during an inversion, leading to poor air quality, creating a health and safety risk. Additionally, when the temperature drops below the dewpoint temperature, fog may form in the surface layer, reducing visibility and hindering the movement of mine equipment, impacting operations, and creating an increased operational safety risk.

4 Risk Assessment

Risks scores were calculated under current climate conditions to establish a baseline, as well as for the three future time horizons (2020s, 2050s and 2080s), and for two SSPs; SSP2-4.5 and SSP5-8.5. The risks discussed in this report are primarily based on SSP5-8.5 as the global trends in GHG emissions and future socio-economic considerations are currently closest to following this pathway.

A risk rating was developed for each climate hazard-infrastructure interaction, by assigning each interaction a consequence score and multiplying the consequence score by the likelihood of the climate hazard exceeding the defined climate threshold. The risk rating is calculated using the following equation:

Risk = Likelihood of Climate Hazard Occurring x Consequence of Impact of Occurrence

Likelihood represents the probability of occurrence of a climate hazard above an identified threshold expected to negatively impact the asset or infrastructure component. Likelihood scores range from 1 (Rare) to 5 (Almost Certain).[5]

Consequence of Impact is a rating of the impact (i.e., damage or loss of service) to the asset or infrastructure component should the climate event occur. Consequence scores range from 1 (Very Low) to 5 (Very High).

Using Consequence scores of 1 to 5 and Likelihood ratings of 1 to 5 produces a 5x5 risk matrix with risk ratings ranging from 1 to 25 as shown in Table 9.

Table 9 Risk Ratings – Evaluation Matrix

Consequence	Very High	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very Low	1	1	2	3	4	5
			1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost Certain
			Likelihood				

General risk adaptation and mitigation responses are provided in Table 10. Adaptation and mitigation measures were developed for all catastrophic, high, and select moderate risks that were deemed to require adaptation responses, based on professional judgment.

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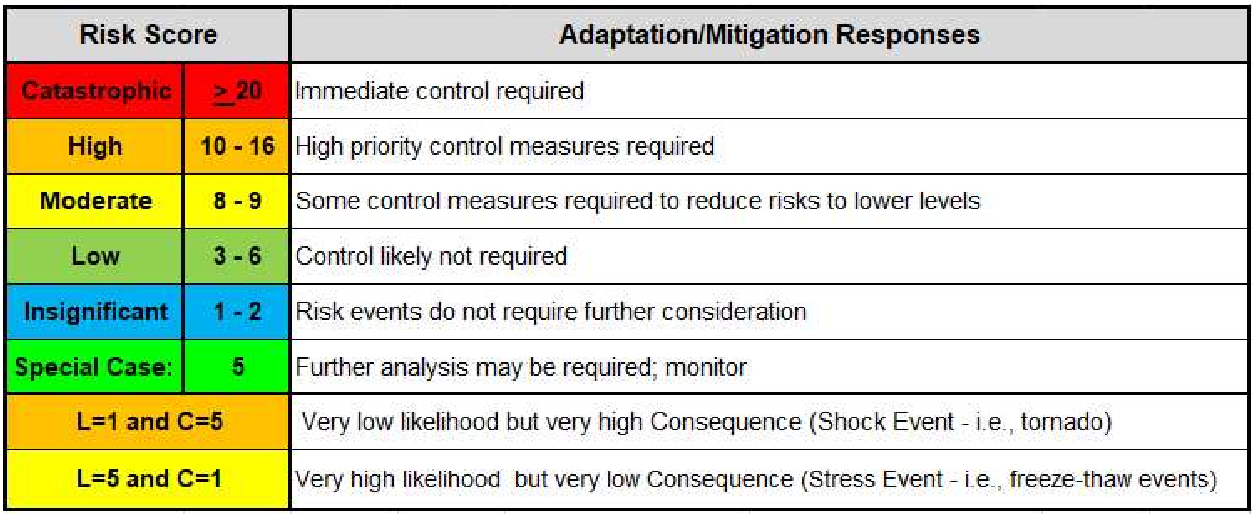
[5] Likelihood and Consequence scoring classifications have been selected to align with Canadian Nickel Company Enterprise Risk Management practices.

Risks with risk scores of 5 are considered ***"special cases"***. Special case risks with a very low likelihood of occurrence (L = 1) but have a very high consequence of impact (C = 5), are classified as **"shock events".** Shock events (i.e., tornadoes, major floods) occur infrequently but have the potential to cause substantial damage to an infrastructure component, so are classified as high risks events.

Special case risks with an associated likelihood score of 5 (L = 5) having a very low consequence of impact (C = 1) are classified as **"stress events".** Stress events (i.e., freeze-thaw) which can have a cumulative effect on assets and infrastructure components related to increased frequency of occurrence, are classified as moderate risks.

Table 10 Risk Classifications and Generalized Adaptation/Mitigation Responses



Risk Score		Adaptation/Mitigation Responses
Catastrophic	≥ 20	Immediate control required
High	10 - 16	High priority control measures required
Moderate	8 - 9	Some control measures required to reduce risks to lower levels
Low	3 - 6	Control likely not required
Insignificant	1 - 2	Risk events do not require further consideration
Special Case:	5	Further analysis may be required; monitor
L=1 and C=5		Very low likelihood but very high Consequence (Shock Event - i.e., tornado)
L=5 and C=1		Very high likelihood but very low Consequence (Stress Event - i.e., freeze-thaw events)

4.1 Consequence Scoring Criteria

A consequence in the context of the CCRA is defined as a measure of the impact to an asset or infrastructure component caused by a climate hazard. Consequence criteria were selected to capture the effects that the selected climate hazard could have on the Project assets and infrastructure should they interact. Six consequence categories were selected which generally align with the Canada Nickel Company Risk Register, are described below.

Structural – The climate hazard results in physical damage or deterioration to the asset or infrastructure component. Examples include fracture or failure, material fatigue or weakening, cracking, deflection, or permanent deformation of the asset/infrastructure component.

Functional – The climate hazard results in a reduction in the function or design capacity (functionality) of the asset/infrastructure component and its ability to perform at its rated design capacity. For example, a partially blocked culvert will limit the volume of water flowing through the culvert to be below the design capacity of the culvert.

Operations and Maintenance – The climate hazard will affect the ability of staff to perform repairs, O&M requirements, and determine if external support (e.g., contractors or specialized technicians) are required to address the asset/infrastructure impacts. The climate impacts can result in increased O&M costs (additional staffing, overtime, emergency response) and may require capital expenditures to fully correct.

Health and Safety – The climate hazard results in health, safety, and/or medical impacts to workers. Examples include temperature-related health hazards (e.g., heat exhaustion, heat stroke) and physical injuries related to slips and falls caused by ice formation due to extreme cold, freezing rain and freeze-thaw events.

Environmental – The climate hazard results in contamination to the air, land, water, and/or ecosystems that may require remediation, monitoring and/or reporting of the incident to the Province, Federal Government and/or local conservation authority.

Financial – The financial impacts of the climate hazard to Canada Nickel as measured by the impact on operating cash flow.

The types of impacts and criteria for each consequence score used to provide a framework and guide to assigning representative numerical consequence scores for each climate hazard-asset/infrastructure component interaction are described in Table 11.

4.1.1 Summary of Consequence Scores

Each climate hazard and asset/infrastructure interaction was assessed and a consequence score assigned for each occurrence. A summary of the consequence scores for each asset/infrastructure component and climate hazard interaction is presented in Table 12.

Consequence scores ranged from very low (score = 1) to a maximum score of 3 or moderate. Moderate consequences were associated with:

- Extreme cold temperature impacts on the proposed spur rail line, relating to contraction and potential fracturing of rails.
- Long and short duration rainfall impacts on the TMF, Open Pit operations, and Water Management System.
- Freezing rain impacts on the trolley assist system associated with ice accumulation on trolley wires.
- Wind impacts to primary/secondary crushing facilities associated with increases in fugitive dust.

Table 11 Consequence Rating Table

Consequence Score	Qualitative Descriptor	Structural	Functional	Operations and Maintenance	Health and Safety	Environment	Financial (Op. Cash Flow)
5	Very High	• Impact/damages result in loss or destruction of asset or infrastructure component. • Special funding/approvals required • Extended time (months) required to repair/restore asset/infrastructure component.	• Large scale disruptions to building systems, operations and utilities - may require emergency planning responses. • Site or large portions of mine operations are inaccessible or offline. Full restoration takes months.	• Work required to address issues is hazardous to staff. • System/components require upgrades/replacement due to inability to replace individual components. • May take months to repair/restore system and/or components.	• Multiple fatalities or major loss of quality of life.	• Severe regional impact resulting in permanent long-term impact to the environment. • Mine operations severely impacted - long term shutdown required. Possible loss of mine. • Potential for long term reputational impact.	• Extreme financial losses from impacts to facilities, operations, communities and/or the environment (>$500M)
4	High	• Impacts/damage require a large cost to repair/replace components. • Costs exceed planned O&M budget. • Requires additional capital funding and outside resources to correct. •Takes weeks to months to repair/restore asset, infrastructure components and operations.	• Buildings and operations continue but may experience extended disruptions (weeks to months). • Requires management interventions. • Site access, operations and supporting services likely to be interrupted.	• Costs exceed O&M budget by large amount - may require special approvals. • Maintenance using additional resources and outside assistance is required to address situation. • May take weeks to months to repair/restore asset and operations.	• Single fatality or critical injury with a permanent negative impact to quality of life for one person.	• Large impact with medium to long-term impairment and residual ecosystem effects. • Regulatory agency mandated remediation and/or monitoring over a long-term period to determine extent of adverse environmental impact. • Mine operations need to be temporarily shut down. • Resumption of operations with months. • Immediately reportable to the Ministry of the Envirinment (MOE).	• Very high financial losses from impacts to facilities, operations, communities and/or the environment (>$100M - <$500M)
3	Moderate	• Impacts/damage is manageable; repair costs may exceed planned O&M budgets. • Component replacement periods may be shorter than standard lifespans. • Repairs/replacement takes weeks to correct.	• Building systems and operations are temporarily disrupted requiring intervention actions. • Restoration time takes days to weeks. • Site access is reduced/limited but not stopped.	• Operational costs may increase by a modest amount. • Additional time and resources above normal staffing levels required. • May require outside /specialty contractors to correct. • May take several days to weeks to repair/restore system/components and operations.	• Serious injury to one or more persons resulting in temporary negative impact to quality of life (long term injury or restricted duty injury).	• Moderate impact resulting in medium-term impacts to the environment • Remediation completed in compliance with regulations over a medium-term period without any anticipated residual adverse environmental impacts. • Potentially reportable to the MOE, but not immediately.	• High financial losses from impacts to facilities, operations, communities and/or the environment (>$10M - <$100M)
2	Low	• Impacts can be corrected within current O&M budget. • Some extra costs to repair with little or no capital requirements.	• Process operations are affected, but can continue at reduced rate. • Repairs or replacement can be completed during scheduled shutdowns. • Mine production is reduced but not stopped.	• Operational costs may increase by a small amount. • Repairs can be corrected with existing O&M resources. • Repairs or replacement can be completed during scheduled shutdowns.	• Reversible injury to one person, (no lost time or work performance) but requiring medical treatment.	• Localized, minor impact within the current or planned disturbance area (or isolated offsite impacts). • Limited remediation and or controls required to meet regulatory standards. • Potentially reportable incident to the , but not immediately.	• Moderate financial losses from impacts to facilities, operations, communities and/or the environment (>$1M - <$10M)
1	Very Low	• Limited to no damage to assets, infrastructure components and operations.	• Limited to no impact to assets, infrastructure components and operations.	• Can be corrected during regular routine maintenance. • No impact to O&M budgets.	• Minor injury not affecting work performance and requiring only a single first aid treatment.	• Environmental incident within an area already disturbed by operations, with short-term impacts. • Remediation carried out as part of routine process. Not reportable to the MOE.	• Limited financial impacts (<$1M)

Table 12 Summary of Consequence Scores for the Crawford Nickel Project Assets and Infrastructure

Asset	Infrastructure Category	Infrastructure Component	Extreme Heat						Heat Wave						Extreme Cold						Freeze-thaw cycles						Short Duration High Intensity Rainfall						Long Duration Rainfall						Heavy Snow						Freezing Rain						Wind Gusts						Drought					
			Days with Tmax ≥30°C						Tmax ≥30°C for Three or More Consecutive Days						Days with Tmin ≤ -30°C						Occurrence of 30 Freeze-thaw Cycles Annually						50 mm Rain in 1 hr						100 mm Rain in 24 Hours						25 cm Snow in 24 Hours						10-15 mm of Ice Accumulation						Wind Gusts > 90 km/hr						SPEI12 < -1					
			S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin	S	F	O&M	H&S	Env	Fin
Buildings	Administrative and Support Buildings (Modular)	Plant Offices		2	1	1				2	1	1				2	1						1	2																							2	2			2	2	2	1								
		Medical Clinic and Firehall		2	1	1				2	1	1				2	1						1	2																							2	2			2	2	2	1								
		Gatehouse		1		1				1		1				2	1																																		2	2	2	1								
		Assay Lab																																																			2	2	2	1								
		Explosives Manufacture and Storage Facility																									1	1	1				1	1	1																									
	Mine Infrastructure Buildings (Pre-engineered)	Plant Maintenance Buildings/ Workshops/ Garages		2	1	1				2	1	1				2	1						1	2																							2	2			2	2	2	1								
		Warehouses																					1	2																							2	2			2	2	2	1								
	Process Plant Buildings (Pre-engineered)	Primary/Secondary Crushing and Crushed Ore Stockpile Cover (Geodesic Dome)																																																			2	2	2	1								
		Conveyors and Crushed Ore Tunnel																																																			2	2	2	2								
		Process Plant Building		2	1	1				2	1	1											1	2																							2	2			2	2	2	1								
		Thickener																																																														
		Concentrate Loadout Buildings																																																			2	2	2	1								
Open Pit, Ore and Waste Storage	Open pit	Access/Haulage Roads/Berms			1	1					1	1															2	2	2	1	1	1	2	2	2	1	1	1		2	2	1				2	2	2					2	2								
		Mining Equipment (trucks/shovels/dozers)		2	2	2		1		2	2	2		1	2	2	2			1																										2	2	2														
		Pit operations (blasting/hauling/surveying)			2	2					2	2				2		2					1	2			2	2	2				3	3	3	3	3	2		2	2	1				2	2	2					2	2								
		Dewatery System and Equipment		2	2	2		1		2	2	2		1	2	2	2											3	2					3	2																											
		Trolley System																																						2	2				1	3	2			1	2	2	2	2		1						
	Ore/Waste Stockpiles	Rock, Sand, Till and Clay Stockpiles and Impoundments				1						1															2		1		1		2		1		1																	2								
		West and East Ore Stockpiles, Overburden Stockpiles				1						1															2		1		1		2		1		1																	2								
Tailings Management Facility (TMF)	Main TMF Storage Area	Containment Dam/Berms, Liner, Spillways																									2	2	2	2	3	1	2	2	2	2	3	1																								
	TMF Tailings Transport and Management	Pumps/Pipes/Valves/Controls and Monitoring													2	2	2										2	2	2	2	3	1	2	2	2	2	3	1																								
Site Services	Site Power	Electrical Substations		2				1		2				1																																																
		Power/Plant Distributions		2				1		2				1																																																
		Standby/Emergency Power Supply		2	2			1		2	2			1		1	1																							1	1					2	2					2	2									
	Fuel Farm	Diesel, Gasoline, and Diesel Exhaust Fluid Storage		1	1											1	1																																													
	Potable Water	Potable Water Treatment Plant and Storage Tank.		1						1					2	2	2																																													
	Service Water	Piping, Pumps, Water Source and Treatment													2	2	2																																													
	Wastewater	Waste Water Treatment Plants																																																	2	2	2	1								
	Site Water Management	Ditches, stormwater ponds, drainage slopes																				2					2	2	2		1		2	2	2		1			2	2																					
	Roadways	Access & Site Roads	2		1										2		1				2		2					2		2				1		2				1	1					2	1	2														
Third Party Services	Power Supply	High-voltage powerlines, poles/towers, transformers, substations		2				1		2				1																															2	2	2				2	2	2									

4.2 Discussion of Risk Results

A summary of the highest risk ratings for each infrastructure component and climate hazard interaction for all time horizons under SSP5-8.5/RCP 8.5 is presented in Table 13. The risks shown are only the highest risks recorded for each climate hazard–asset/infrastructure interaction.

- All risks remain constant or show an increasing trend from baseline climate to the 2080s, except for extreme cold and freeze-thaw cycles, which have a declining risk trend because of the general warming temperatures under climate change.
- The highest risk number of risks were associated with wind gusts potentially impacting most buildings, the open pit and trolley system, and the third-party power supply to the mine. Wind gusts were found to be a moderate risk (Risk = 8) under baseline climate, 2020s and 2050s increasing to high risks (Risk = 10) for these assets by the 2080s.
- Other notable climate hazards that pose a high risk to project infrastructure include extreme heat, heat waves, and long-duration rainfall.
    - HVAC systems and cooling systems on buildings are at high risk (Risk = 10) from extreme heat and heat waves in the 2020s, 2050s and 2080s. Higher ambient temperatures reduce the ability of HVAC equipment to provide sufficient cooling to maintain building temperatures at the required comfort level.
    - Extreme heat and heat waves may increase the risk of heat-related illness, especially for workers working outdoors or in spaces without air conditioning.
    - Extreme heat and heat waves can also affect the mining equipment, which may overheat and shorten the service life of the equipment.
    - Long-duration rainfall poses high risks to pit operations and water management systems from localized flooding and overwhelming of pumps, leading to potential equipment damage and disruption to operations. These risks are low under baseline climate and the 2020s, increasing to high risks in the 2080s. The Tailings Management Facility is at moderate risk in the 2050s and high risk in the 2080s from long duration rainfall.

Risk Score
Catastrophic
High
Moderate
Low
Insignificant

Table 13 Summary of Highest Risk Ratings for SSP5-8.5/RCP 8.5 for All Time Periods

Climate Hazard			Extreme Heat				Heat Wave				Extreme Cold				Freeze-thaw cycles				Short Duration High Intensity Rainfall				Long Duration Rainfall				Heavy Snow				Freezing Rain				Wind Gusts				Drought			
			Days with Tmax ≥30°C				Tmax ≥30°C for Three or More Consecutive Days				Days with Tmin ≤ -30°C				Occurrence of 30 Freeze-thaw Cycles Annually				50 mm Rain in 1 hr				100 mm Rain in 24 Hours				25 cm Snow in 24 Hours				10-15 mm of Ice Accumulation				Wind Gusts > 90 km/hr				SPEI12 < -1			
Asset	**Infrastructure Category**	**Infrastructure element**	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s	Baseline	2020s	2050s	2080s
Buildings	**Administrative and Support Buildings (Modular)**	Plant Offices	6	10	10	10	4	8	10	10	6	2	2	2	6	4	4	4													6	6	6	6	8	8	8	10				
		Medical Clinic and Firehall	6	10	10	10	4	8	10	10	6	2	2	2	6	4	4	4													6	6	6	6	8	8	8	10				
		Gatehouse	3	5	5	5	2	4	5	5	6	2	2	2																					8	8	8	10				
		Assay Lab																																	8	8	8	10				
		Explosives Manufacture and Storage Facility																	1	1	2	2	2	2	3	4																
	Mine Infrastructure Buildings (Pre-engineered)	Plant Maintenance Buildings/ Workshops/ Garages	6	10	10	10	4	8	10	10	6	2	2	2	6	4	4	4													6	6	6	6	8	8	8	10				
		Warehouse													6	4	4	4													6	6	6	6	8	8	8	10				
	Process Plant Buildings (Pre-engineered)	Primary/Secondary Crushing and Crushed Ore Stockpile Cover (Geodesic Dome)																																	8	8	8	10				
		Conveyors and Crushed Ore Tunnel																																	8	8	8	10				
		Process Plant Building	6	10	10	10	4	8	10	10					6	4	4	4													6	6	6	6	8	8	8	10				
		Thickener																																								
		Concentrate Loadout Buildings																																	8	8	8	10				
Open Pit, Ore and Waste Storage	**Open pit**	Access/Haulage Roads/Berms	3	5	5	5	2	4	5	5									2	2	4	4	4	4	6	8	6	6	6	6	6	6	6	6	8	8	8	10				
		Mining Equipment (trucks/shovels/dozers)	6	10	10	10	4	8	10	10	6	2	2	2																	6	6	6	6								
		Pit operations (blasting/hauling/surveying)	6	10	10	10	4	8	10	10	6	2	2	2	6	4	4	4	2	2	4	4	6	6	9	12	6	6	6	6	6	6	6	6	8	8	8	10				
		Dewatering System and Equipment	6	10	10	10	4	8	10	10	6	2	2	2					3	3	6	6	6	6	9	12																
		Trolley System	3	5	5	5	2	4	5	5																	6	6	6	6	9	9	9	9	8	8	8	10				
	Ore/Waste Stockpiles	Rock, Sand, Till and Clay Stockpiles and Impoundments	3	5	5	5	2	4	5	5									2	2	4	4	4	4	6	8									8	8	8	10				
		West and East Ore Stockpiles, Overburden Stockpiles	3	5	5	5	2	4	5	5									2	2	4	4	4	4	6	8									8	8	8	10				
Tailings Management Facility (TMF)	**TMF Storage Area**	Containment Dam/Berms, Liner, Spillways																	3	3	6	6	6	6	9	12																
	TMF Tailings Transport and Management	Pumps/Pipes/Valves/Controls and Monitoring									6	2	2	2					3	3	6	6	6	6	9	12																
Site Services	**Site Power**	Electrical Substations	6	10	10	10	4	8	10	10																																
		Power/Plant Distributions	6	10	10	10	4	8	10	10																																
		Standby/Emergency Power Supply	6	10	10	10	4	8	10	10	3	1	1	1													3	3	3	3	6	6	6	6	8	8	8	10				
	Fuel Farm	Diesel, Gasoline, and Diesel Exhaust Fluid Storage	3	5	5	5	2	4	5	5																																
	Potable Water	Potable Water Treatment Plant and Storage Tank	3	5	5	5	2	4	5	5	6	2	2	2																												
	Service Water	Piping, Pumps, Source Water									6	2	2	2																												
	Wastewater	Waste Water Treatment Plant																																	8	8	8	10				
	Site Water Management	Site Drainage, Ditches,Collection/Storage Ponds													6	4	4	4	2	2	4	4	4	4	6	8	6	6	6	6												
	Roadways	Access Roads & Site Roads	3	5	5	5					6	2	2	2	6	4	4	4	2	2	4	4	4	4	6	8	3	3	3	3	6	6	6	6								
Third-Party Services	**Power Supply**	Overhead high-voltage powerlines	6	10	10	10	4	8	10	10																	3	3	3	3	6	6	6	6	8	8	8	10				

4.2.1 Total Risks and Distribution of Risks by Consequence Category

The total number of risks (328 for all time periods) and distribution of the risks by consequence category for the Project are presented on Figure A.6 (Appendix A). The highest number of risks were associated with Operations and Maintenance impacts (97 risks), largely related to climate-caused damage to buildings and equipment, as well as other climate-related requirements such as increased snow removal, road and process/haulage equipment repairs and maintenance, and the resulting operational and process delays and interruptions.

Functional and Health and Safety consequences comprised 26% and 20% of the total risks respectively. Many of the functional risks are directly related to interruptions to operations and reductions in production caused by impacts to workers and climate-sensitive equipment such as HVAC or power supply. Health and safety risks were predominantly associated with extreme heat and wind impacts, including heat exhaustion, heat stroke, increased fugitive dust, and wind-blown debris.

Structural consequences comprised 13% of total risks relating mostly to extreme cold, short and long duration rainfall events, and wind gusts. Equipment is more susceptible to breaking under extreme cold conditions, when metal becomes brittle. Extreme rainfall can lead to increased erosion of stockpiles and collection ponds, increasing the risk of environmental contamination. Structural consequences from high-intensity rainfall events were also identified for the proposed spur line due to potential slope failure, flooding of tracks, and washout of bridges or culverts.

Financial consequences comprise 7% of total risks, associated with risks from heat waves, extreme heat, long duration rainfall, and short duration high intensity rainfall impacts causing disruptions that would affect operations and production.

4.2.2 Distribution of Risks by Infrastructure Category

Figure A.7 (Appendix A) shows the distribution of risks (328 total) across the 14 infrastructure categories. The highest number of risks (94) are associated with the open pit and related infrastructure components including access/haulage roads and berms, mining equipment, pit operations, water management system, and trolley assist system. Moderate and high risks occur predominantly in the 2050s and 2080s associated with impacts to workers and equipment from extreme heat/heat waves and cold temperatures, long duration rainfall affecting pit operations (e.g., blasting, surveying), and wind gusts impacting the trolley system and H&S impacts to workers related to fugitive dust.

Administrative/support buildings had the second-most risks (63) related to plant offices, medical clinic and firehall, gatehouse, assay lab, water management system, and explosives storage facility. Moderate and high risks were related to functional impacts to the HVAC systems caused by extreme heat and heat waves, and possible structural, functional and O&M impacts from wind gusts.

The TMF comprised the third-most risks (27) associated with short duration high-intensity and long duration rainfall affecting the containment dam, berms, liners, spillways, pumps, pipes, valves and controls. Highest risks occurred in the 2080s related to environmental impacts, causing increased potential for saturation of the berms and increased water levels on the tailings.

4.2.3 Distribution of Risks by Climate Hazard

The distribution of risks across the ten climate hazards selected for the assessment is illustrated on Figure A.8 (Appendix A). Wind gusts (64), extreme heat (44), and heat waves (42) are responsible for the highest number of risks to Project infrastructure.

- Wind gusts are associated with 52 high risks and 12 moderate risks by the 2080s. High risks are predominantly related to potential structural damage to modular and pre-engineered buildings, increase in fugitive dust, and health and safety hazards from wind-blown debris and dust.
- Extreme heat is associated with 18 high risks and 26 moderate risks while heat waves are associated with 17 high risks and 25 moderate risks. Risks are related to increased cooling demand on HVAC systems in most buildings, potential transformer failures and related power outages, increased fugitive dust and related O&M dust suppression requirements, and increased potential for heat-related illnesses for workers.
- Long duration rainfall is associated with 8 high risks and 19 moderate risks affecting the TMF, pit operations and access, dewatering system, roads and ore/waste stockpiles..

4.2.4 Risk Trends

The total number of risks by risk category are presented on Figure A.9 (Appendix A). The number of negligible and low risks are highest under baseline and in the 2020s, and generally decline in the 2050s and 2080s. Moderate and high risks are lower in the baseline and 2020s, increasing in the 2050s and 2080s. These trends are generally a result of increasing likelihood of the occurrence of the climate hazards under future climate scenarios. Most notably, the number of high risks increase by 400% from the 2020s to the 2080s, from 19 in the 2020s to 95 in the 2080s. Conversely, the number of low and negligible risks decline by 45%, from 272 risks under baseline to 144 risks in the 2080s.

4.2.5 Risk Trends Under SSP2-4.5 and SSP5-8.5

The risk scores for Project assets and infrastructure under SSP2-4.5 and SSP5-8.5 are presented on Figure A.10 (Appendix A). Most of the data and information presented in this report are based on SSP5-8.5, as this pathway closely reflects the current greenhouse gas emissions and socio-economic trajectory. Using a lower GHG forcing scenario or socio-economic pathway could lead to underestimating the climate risks to the Project.

The general number of risks under SSP2-4.5 and SSP5-8.5 are very similar for extreme heat, heat waves, extreme cold, freeze thaw, short duration rainfall, heavy snow and freezing rain, which would indicate climate change mitigation for these scenarios will have a limited impact on the total number of risks. The risk profiles for long duration rainfall and wind gusts do change substantially under the middle of the road (SSP2-4.5) and business as unusual (SSP5-8.5) scenarios.

- The number of high risks associated with wind gusts increases dramatically, from 1 under SSP2-4.5 to 52 under SSP5-8.5. It has been noted previously that the effects of climate change on wind gusts is not as well understood as other climate variables, such as temperature. Current understanding is winds have the potential to increase under effects of future changes in climate (Cheng et al., 2014).
- The number of moderate and high risks associated with long duration rainfall increases from 4 and zero to 18 and 52 under SSP2-4.5 and SSP5-8.5, respectfully. Precipitation events are projected to become more intense by the 2080s, increasing by 31.6% under SSP2-4.5 and 58.9% under SSP5-8.5, respectively, for all design storms ranging from 5 minute to 24-hour duration and 2 to 100-year return frequency when compared to historical IDF curves.

5 Risks and Resilience/Adaptation Measures

Climate risks and impacts are important considerations during the full LOM, from early planning and design through operations to closure and post closure activities and monitoring. Risk management strategies form a continuum, from reactive actions that focus on reducing the consequences associated with risks, to proactive actions, which involve planning to avoid or reduce the occurrence of the risk (Figure A.11, Appendix A). The preferred approach is to avoid risks or develop adaptation and/or risk avoidance measures, where possible, to reduce the risks to acceptable levels, supported by organizational policies and procedures to manage the risks and develop risk response strategies to reduce the consequences.

Resilient design must be an integral part of the Project planning process to assess risks to the Project from climate hazards in the context of the Project's purpose, asset type, site location, and finances, and then determine the appropriate climate adaptation and mitigation strategies to meet the resiliency objectives of the Project.

Mitigation strategies to reduce (or eliminate) the risks can range from proactive adaptation to active O&M management, and finally reactive responses and emergency response planning. Generally, the objective is to adapt, where possible, but where this is not feasible, risks will need to be mitigated through management and/or purpose-based response strategies.

The intent of the CCRA is to find the balance between mitigation and resilience by identifying current and future climate-related risks to the Project assets, infrastructure, and operations, and develop climate adaptation and resilience measures that can be considered by Canada Nickel to reduce the physical impacts of climate change to the Project, and in doing so, reduce the impacts to the environment.

5.1 Quantitative Risks and Adaptation/Resilience Recommendations

Recommended adaptation measures for moderate and high climate risks that could negatively impact the Project are presented in Table 14 specific to the planned assets and infrastructure components. The consequence criteria in red text indicate those criteria that produce the highest risk scores for each interaction. Multiple criteria in red indicates several consequence criteria are associated with the highest risk scores for the associated climate hazard-infrastructure and/or services interaction.

The adaptation measures provided are not exhaustive and should be used as a guide to develop further Project site and infrastructure specific adaptations to reduce the risks caused by the identified climate hazards. The measures are provided for consideration by Canada Nickel to help build resilience to climate change and extreme weather events into the ultimate mine designs and operational plans.

In addition to the adaptation strategies provided, it should be noted many risks can be efficiently and effectively addressed and reduced through O&M policy considerations and the development of SOPs. The suggested O&M policies and SOPs presented should be reviewed and revised on a regular basis to address current and future impacts to Project assets and workers.

Table 14 Resilience/ Adaptation Considerations for Crawford Nickel Project

Mine Site Asset	Infrastructure Category	Infrastructure Component	Climate Hazard	Highest Risk					High level Impacts/Impacts Statements	Resilience/Adaptation Considerations
				Risk Legend Negligible	Low	Moderate	High	Extreme		
				Baseline	2020s	2050s	2080s	Consequence Criteria*		
Buildings	Administrative/ Support Buildings	Plant Offices Medical Clinic and Firehall Gatehouse	Extreme Heat	6	10	10	10	F, O&M, H&S	1. Extreme heat increases the cooling demand on building HVAC systems, which may result in insufficient cooling to consistently maintain building set points to provide a proper comfort level for staff. Air conditioning units will produce less cooling as ambient air temperatures rise 2. Higher temperatures increased the risk of heat related injuries to workers (increase risk of heat fatigue and heat stress), specially in the maintenance shop bays which are frequently open and lack cooling. 3. Extreme heat results in higher equipment operating temperatures leading to increased maintenance and risk of failure. 4. Extreme heat increases evaporationtranspiration, which can lead to an increase in fugitive dust and the associated material loss and can lead to an increased risk of forest fires. 5. Extreme heat increases evapotranspiration, which reduces the water levels in collection ponds and decreases the volume of water needed to be treated before being released to the environment.	1. When designing administrative buildings, consider a high level of insulation in the building envelope (walls, windows, roof, foundation (Insulated Concrete Foundation (ICF)) to decrease the cooling (and heating) demand. 2. Consider using climate adjusted design criteria to size HVAC systems for future cooling loads. 3. For air-cooled air-conditioning units, investigate the use of spray water cooling for the compressor to increase the cooling capacity under extreme heat and heat waves. 4. Review and update health and safety policies to reflect risks to workers from increasing temperatures caused by climate change. 5. Design natural cooling into buildings where HVAC cooling will be insufficient or not feasible. Consider cross ventilation and heat chimneys to remove hot air where possible. Install fans to increase air movement to facilitate natural cooling. 6. Consider providing cooling stations and increasing the frequency of breaks for workers to reduce the risk of heat-related illnesses.
			Heat Waves	4	8	10	10	F, O&M, H&S		
			Wind Gusts	8	8	8	10	S, F, O&M, H&S	1. Potential for structural damages to buildings; high winds can damage roof and building envelope, windows and doors. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust.	1. Consider selecting modular and pre-engineered buildings with higher resilience to lateral loading. 2. Consider installing hoods, fans, and fabric filters where possible to enclose and vent dusty processes. 3. Reduce dust by wetting material using spray bars or water trucks during dry conditions, minimizing drop heights, limiting activities during extreme winds, re-vegetating areas that are no longer in use, and applying dust-suppression treatments to roadways. 4. Implement O&M programs to inspect air filtration systems on HVAC equipment to maximize removal of fugitive dust and other airborne contaminants. Adjust the frequency of filter inspections/changes to reflect increased amounts of dust produced by dry or windy conditions.
		Assay Lab	Wind Gusts	8	8	8	10	S, F, O&M, H&S	1. Potential for structural damages to buildings; high winds can damage roof and building envelope, windows and doors. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust. 3. Increased potential for contamination of samples during processing in the lab.	1. Consider selecting modular and pre-engineered buildings with higher resilience to lateral loading. 2. Inspect and maintain window and door seals and air filtration systems to minimize dust contamination in the lab. Consider installing hoods, fans, and fabric filters where possible to enclose and vent dusty processes. 3. Consider reducing dust by using spray bars to reduce dust on conveyors, increase the use of water trucks during dry conditions, minimize drop heights during material handling, limit activities during extreme wind events, revegetate areas that are no longer in use, and apply dust-suppression treatments to roadways. 4. Implement O&M programs to inspect air filtration systems on HVAC equipment to maximize removal of fugitive dust and other airborne contaminants. Adjust the frequency of filter inspections/changes to reflect increased amounts of dust produced by dry or windy conditions.
		Tailings Pumphouse	Extreme Cold	9	3	3	3	S, F, O&M, Fin	1. Extreme cold can freeze tailings process and transporation/distribution pipes and valves. 2. Increase in maintenance and potential reduction in production due to frozen pipes and valves.	1. Install drain valves in pipes that may be susceptible to freezing. 2. Consider insulating pipes and/or installing heat trace on process pipes susceptible to freezing. Consider installing temperature sensors to monitor critical piping exposed to freezing temperatures. 3. Where possible, have pipes configured to self drain to reduce the risk of freezing.

* Consequence criteria shown in **Red Text** are associated with the highest risks scores for the climate hazard-infrastructure and/or services interaction.

LEGEND- CONSEQUENCE CATEGORIES					
S	Structural	O&M	Operations and Maintenance	EV	Environmental
F	Functional	H&S	Health and Safety	Fin	Financial

Table 14 Resilience/ Adaptation Considerations for Crawford Nickel Project

Mine Site Asset	Infrastructure Category	Infrastructure Component	Climate Hazard	Highest Risk					High level Impacts/Impacts Statements	Resilience/Adaptation Considerations
				Risk Legend						
				Negligible	Low	Moderate	High	Extreme		
				Baseline	2020s	2050s	2080s	Consequence Criteria*		
Buildings	Mine Infrastructure Support Buildings	Plant Maintenance Buildings/ Workshops/ Garages and Warehouses	Extreme Heat	6	10	10	10	F, O&M, H&S	1. Extreme heat increases the cooling demand on building HVAC systems, which may result in insufficient cooling to consistently maintain building set points to provide a proper comfort level for staff. Air conditioning units will produce less cooling as ambient air temperatures rise 2. Higher temperatures increased the risk of heat related injuries to workers (increase risk of heat fatigue and heat stress), specially in the maintenance shop bays which are frequently open and lack cooling. 3. Extreme heat results in higher equipment operating temperatures leading to increased maintenance and risk of failure. 4. Extreme heat increases evaporationtranspiration, which can lead to an increase in fugitive dust and the associated material loss and can lead to an increased risk of forest fires. 5. Extreme heat increases evapotranspiration, which reduces the water levels in collection ponds and decreases the volume of water needed to be treated before being released to the environment.	1. When designing administrative buildings, consider a high level of insulation in the building envelope (walls, windows, roof, foundation (Insulated Concrete Foundation (ICF)) to decrease the cooling (and heating) demand. 2. Consider using climate adjusted design criteria to size HVAC systems for future cooling loads. 3. For air-cooled air-conditioning units, investigate the use of spray water cooling for the compressor to increase the cooling capacity under extreme heat and heat waves. 4. Review and update health and safety policies to reflect risks to workers from increasing temperatures caused by climate change. 5. Design natural cooling into buildings where HVAC cooling will be insufficient or not feasible. Consider cross ventilation and heat chimneys to remove hot air where possible. Install fans to increase air movement to facilitate natural cooling. 6. Consider providing cooling stations and increasing the frequency of breaks for workers to reduce the risk of heat-related illnesses.
			Heat Waves	4	8	10	10	F, O&M, H&S		
			Wind Gusts	8	8	8	10	S, F, O&M, Fin	1. Potential for structural damages to buildings; high winds can damage roof and building envelope, windows and doors. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust.	1. Consider installing hoods, fans, and fabric filters where possible to enclose and vent dusty processes. 2. Consider minimizing dust by wetting material using spray bars or water trucks during dry conditions, minimizing drop heights, limiting activities during extreme winds, re-vegetating areas that are no longer in use, and applying dust-suppression treatments to roadways. 3. Implement O&M programs to inspect air filtration systems on HVAC equipment to maximize removal of fugitive dust and other airborne contaminants. Adjust the frequency of filter inspections/changes to reflect increased amounts of dust produced by dry or windy conditions. 4. Install fans to facilitate air movement when doors are closed.

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Table 14 Resilience/ Adaptation Considerations for Crawford Nickel Project

Mine Site Asset	Infrastructure Category	Infrastructure Component	Climate Hazard	Highest Risk Risk Legend Negligible Baseline	 Low 2020s	 Moderate 2050s	 High 2080s	 Extreme Consequence Criteria*	High level Impacts/Impacts Statements	Resilience/Adaptation Considerations
Buildings	Process Buildings	Primary/Secondary Crushing and Crushed Ore Stockpile Cover (Geodesic Dome)	Wind Gusts	12	12	12	15	S, F, O&M, H&S	1. Potential for structural damages to dome; high winds can damage roof panels and structural frame. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust.	1. If possible design openings in dome cover to reduce wind loading and risk of damage during high wind events. 2. Consider minimizing dust by wetting material on conveyors using spray bars and minimizing drop heights. 3. Maintain conveyor belt tensioners to eliminate belt flap and tracking during wind events. 4. Maintain sufficient material on conveyors to reduce damage during high wind events. 5. Consider conveyor covers or wind blocks to reduce the effects of wind on conveyors.
		Conveyors and Crushed Ore Tunnel	Wind Gusts	8	8	8	10	S, F, O&M, H&S	1. Increase in fugitive dust, and dust suppression 2. requirements. Potential for structural damages to conveyor operations.	
		Process Plant Buildings	Extreme Heat	6	10	10	10	F, O&M, H&S	1. May lead to more operational shutdowns due to higher equipment temperatures exceeding operating range. 2.Increase in equipment/equipment component failures due to shorten life expectancy under higher operating temperatures. 3. Increased temperatures may affect the ore treatment (chemical reactions) and recovery systems. 4. Higher temperatures increased the risk of heat related injuries to workers (increase risk of heat fatigue and heat stress), specially in the maintenance shop bays which are frequently open and lack cooling. 5. In extreme cases, temperatures in parts of facilities may create unsuitable working conditions for personnel. 6. Air conditioning units will produce less cooling as ambient air temperatures rise.	1. When designing and construction new buildings, or substantial updating existing, consider a high level of insulation in the building envelope (walls, windows, roof, foundation (Insulated Concrete Foundation (ICF)) to right size the HVAC system. 2. Consider using climate adjusted design criteria to design and size HVAC equipment to will be capable of providing sufficient cooling over the service life of the equipment . 3. For air cooled air conditioning units, investigate the use of spray water cooling to increase the cooling capacity under extreme heat and heat waves. 4. Design natural cooling into buildings where HVAC cooling will be insufficient or not feasible. Consider cross ventilation and heat chimneys to remove hot air where possible. Install fans to increase air movement to facilitate natural cooling. 5. Consider providing cooling stations and increasing the frequency of breaks for workers to reduce the risk of heat related illnesses.
			Heat Waves	4	8	10	10	F, O&M, H&S		
			Wind Gusts	8	8	8	10		1. Potential for structural damages to buildings; high winds can damage roof and building envelope, windows and doors. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust.	1. Consider installing hoods, fans, and fabric filters where possible to enclose and vent dusty processes. 3. Consider minimizing dust by wetting material using spray bars or water trucks during dry conditions, minimizing drop heights, limiting activities during extreme wind, re-vegetating areas that are no longer in use, and applying dust-suppression treatments to roadways.
		Concentrate Loadout Buildings	Wind Gusts	8	8	8	10	S, F, O&M, H&S	1. Potential for structural damages to buildings; high winds can damage roof and building envelope, windows and doors. 2. Health and safety hazards to mine personnel from flying debris and increased fugitive dust.	1. Consider minimizing dust by wetting material using spray bars during dry conditions. 2. Minimizing drop heights when loading materials. 3. Install a ventilation system to remove dust from the building. Consider increasing the number of air turnovers to improve the air quality in the building.

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Table 14 Resilience/ Adaptation Considerations for Crawford Nickel Project

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				Risk Legend						
				Negligible	Low	Moderate	High	Extreme		
				Baseline	2020s	2050s	2080s	Consequence Criteria*		
Open Pit, Ore and Waste Storage	Open Pit	Dewatering System and Equipment	Extreme Heat	6	10	10	10	S, F, O&M, Fin	1. May lead to more operational shutdowns due to higher equipment temperatures exceeding operation range. 2.Increase in equipment/equipment component failures due to shorten life expectancy under higher operating temperatures.	1. Considering increasing the size of cooling systems on equipment to better maintain the operating temperatures. 2. For electric motors, regularily inspect and clean air vents used to cool motors.
			Heat Waves	4	8	10	10	S, F, O&M, Fin		
			Long Duration Rainfall	6	6	9	12	F, O&M	1. Extreme rainfall may exceed capacity of pumps, leading to potential flooding of pit and disruptions to blasting, surveying, and hauling operations	1. Consider sizing dewatering systems using climate adjusted rainfall projections to reduce the risk of localized flooding in the pit.
		Trolley System	Extreme Heat	3	5	5	5	F, O&M	1. Extreme heat may result in power loss to the site and cascading disruptions to the trolley system, resulting in increased diesel consumption	1. Consider maintaining sufficient on-site stock of diesel fuel in the event of prolonged power disruptions. 2. Develop load-shedding procedures for on-site substations to reduce the likelihood of transformer failures.
			Heat Waves	2	4	5	5	F, O&M		
			Freezing Rain	9	9	9	9	S, F, O&M	1. Ice accumulation on trolley wires may impact the operation and functionality of the trolley system. 2. Damage or sagging of trolley wire may occur due to the weight of accumulated ice.	1. Consider loading from freezing rain in the design of trolley system wires and poles. 2. Consider implementing O&M policies to clear ice from trolley wires in the event of freezing rain or ice storms.
			Wind Gusts	8	8	8	10	S, F, O&M, H&S, Fin	1. High wind could cause contact issues with the pantograph. 2. Winds may damage the trolley support system.	1. Consider using climate adjusted wind projections in trolley design to promote resilience to high winds. 2. Consider spacing wires sufficiently to avoid wire slap and improve pentograph contact.
	Ore/waste Stockpiles	Rock, sand, till and clay impoundments East and West Ore Stockpiles	Extreme Heat	3	5	5	5	H&S	1. Hotter temperature increase evaporation, which can lead to an increase in fugitive dust and the associated material loss.	1. If possible, store coarser material on top of finer material. 2. Apply water or chemical suppression regularly
			Heat Waves	2	4	5	5	H&S		
			Long Duration Rainfall	4	4	6	8	S, O&M, Env	1. Extreme rainfall may cause erosion of rock, sand, clay and till stockpiles and impoundments. 2. , leading to interruptions to operations and restorative actions.	1. Consider reducing slopes of impoundments and stockpiles to reduce scouring and washout of material. 2. Cap Material?
			Wind Gusts	8	8	8	10	H&S	1. Wind gusts can increase the erosion of rock, sand, clay and till stockpiles resulting in material losses. 2. Potential health and safety hazards from flying debris and fugitive dust from rock, sand, clay and till stockpiles.	1. Evaluate dust impacts and material loss using dispersion modelling or CFD (computational fluid dynamics) studies. 2. Consider implementing wind barriers to protect stockpiles and/or collect wind blown material.
Tailings Management Facility	TMF Storage Area	Containment Dam/Berms, Spillways, Liner	Long Duration Rainfall	6	6	9	12	S, F, O&M, H&S, Env, Fin	1. Extreme rainfall may result in soil erosion of berms, and potential overtopping of the berms and spillways. 2. Extreme rainfall can increase the amount of water in the watershed, causing rivers and creeks to rise increasing the potential for flooding and erosion around the mines site. 3. Heavy rainfall increases the risks of runoff, which can wash contaminated materials from the site impacting the environment.	1. Consider sizing spillways, drainage systems and retention ponds using climate-adjusted IDF curves and future climate projections. 2. Select erosion resistant material for the construction of berms. 3. Implement stormwater drainage systems to channel water away from tailings pond berms and spillways
	TMF Tailings Transport	Tailings Pumping and Transport (Pumps, Pipes, Other)		6	6	9	12	S, F, O&M, H&S, Env, Fin	1. Extreme rainfall may raise the level of freeboard in the tailings pond increasing the potential for over topping.	1. Consider managing excess water in tailings ponds using mechanically assisted evaporation. 2. Consider installing emergency pumping system to removed excess freeboard.

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Table 14 Resilience/ Adaptation Considerations for Crawford Nickel Project

Mine Site Asset	Infrastructure Category	Infrastructure Component	Climate Hazard	Highest Risk					High level Impacts/Impacts Statements	Resilience/Adaptation Considerations
				Risk Legend						
				Negligible	Low	Moderate	High	Extreme		
				Baseline	2020s	2050s	2080s	Consequence Criteria*		
Site Services	Site Power	Electrical Substations	Extreme Heat	6	10	10	10	F, Fin	1. Higher temperatures will increase the power demands which can lead to increased transformer hot-spotting and failures, and potential power outages. 2. Increased power failures will require increased dependency on generator power at the mine sites, leading to higher emissions.	1. Consider the use of dynamic monitoring and develop a load shedding plan to cut power to non-essential equipment in the event of excessive load. 2. Consider implementing transformer cooling to reduce operating temperatures. 3. Consider painting or powder coating transformers a light colour to reduce the thermal effects of the sun and reduce transformers operating temperatures. 4. Implement a maintenance program to remove rust on transformers to further reduce the
			Heat Waves	4	8	10	10	F, Fin		
		Power/Plant Distributions	Extreme Heat	6	10	10	10	F, Fin	1. Increased demand on the grid during extreme heat events may cause reliability issues and potential brown or blackouts.	1. Consider installing back up generators to power critical life and process systems each mine site.
			Heat Waves	4	8	10	10	F, Fin		
		Standby/Emergency Power Supply	Extreme Heat	6	10	10	10	F, O&M, Fin	1. Higher temperatures can reduce the capacity of thermal generators and transmission lines. 2. Generators operating in extreme heat may overheat and an shut down.	1. When develop specifications for generators, consider increasing the size of the cooling system so generators don't shutdown due over heating during extreme heat events. 2. Consider installing a water spray system to help maintain engine temperature to prevent shutdown during extreme heat events.
			Heat Waves	4	8	10	10	F, O&M, Fin		
			Wind Gusts	8	8	8	10	F, O&M	1. High wind gusts can damage site power supply and distribution systems, leading to power outages and increased runtimes for generators.	1. Implement O&M policy to regularly inspect, test, and maintain generators to improve availability and reliability. 2. Consider increasing on-site diesel storage for generators to account for longer run-times from prolonged outages.
	Potable Water	Potable Water Treatment Plant and Storage Tank	Extreme Heat	3	5	5	5	F	1. Higher temperatures may cause an increase in demand for water, leading to increased operation of the potable water treatment plant and potential depletion of the potable water storage tank. 2. Extended heat waves can impact availability of raw water sources.	1. Considering increasing volume of on-site potable water storage tanks. 2. Develop O&M policy to increase the frequency of inspections/maintenance of potable water treatment plant during extreme heat events.
			Heat Waves	2	4	5	5	F		
	Site Water Management	Site Drainage, Ditches, Collection/Storage Ponds	Long Duration Rainfall	4	6	8	8	S, F, O&M	1. Extreme rainfall may exceed the capacity of the storm drainage system, resulting in localized flooding and the potential for uncontrolled release of untreated contaminants.	1. Use climate adjusted IDF curves to help size storm drainage systems for future projected rainfall events. 2. Consider re-vegetating areas that are not used for mine operations to increase water retention.
	Roadways	Access Roads & Site Roads	Heavy Snow	6	10	10	10	S	1 Heavy snow can impact roads and bridges, increasing the potential for accidents, resulting in road closures, slowing the transport of workers and resources to and from the Project site. 2. Heavy snowfall can increase the load on roofs, increasing the potential for roof collapse or failure. 3. Large accumulations of snow can lead to increased surface water during periods of melting, causing localized flooding. Rapid melts during spring freshet may cause collection ponds to exceed capacity.	1. Develop SOP to maintain the safety of mine personnel being transported to/from the mine sites during heavy snow and other adverse weather events. 2. Develop a H&S plan to temporarily accommodate mine personnel at mine sites when transportation of personnel is impacted or unsafe due to heavy snow or other weather events. 3. Consider providing transportation to and from the mine sites for workers, to reduce the risks of harm, limit the number of vehicles on site, and reduce the carbon foot print of the mine.
			Long Duration Rainfall	4	4	6	8	H&S	1. Extreme rainfall may lead to ponding of water on roadways, creating unsafe driving conditions and potential disruptions to operations. 2. Extreme rainfall can cause rilling of roads and washouts, increasing O&M requirements and costs.	1. Consider regular grading site and access roads to facilitate drainage off road surfaces. 2. Develop H&S policy to reduce speed limits when weather conditions make driving less safe. 3. Implement mandatory safe driving requirements for all mine site personnel.
Third Party Services	Fuel Farm	Diesel, Gasoline, and Diesel Exhaust Fluid Storage	Extreme Heat	3	5	5	5	F, O&M	1. Fuel may expand under high ambient temperatures, leading to tank venting and spillage.	1. Consider locating storage tanks in covered areas where they are not exposed to direct solar radiation. 2. Consider painting fuel storage tanks a light colour to reduce the thermal effects of the sun.
			Heat Waves	2	4	5	5	F, O&M		
	Power Supply	High-voltage powerlines, poles/towers, transformers, substations	Extreme Heat	6	10	10	10	S, F, Fin	1. High temperatures cause increased demand on the regional electrical grid, leading to potential power failures in the form of black or brown outs. 2. Interruption to third-party power may cause disruptions to mining operations and increased use of generators/backup power	1. Consider installing back up generators to power critical life and process systems. 2. Work with the power supplier to develop an annual inspection of the power transmission pole, lines and corridor to identify potential concerns that could interrupt power supply to the mines. Correct identified issues. 3. Implement O&M policy to regularly inspect, test, and maintain generators to improve availability and reliability.
			Heat Waves	4	8	10	10	S, F, Fin		
			Wind Gusts	8	8	8	10	S, F, O&M	1. Wind gusts may cause damage distribution power lines and poles, leading to power interruptions to third party power providers.	

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5.2 Qualitative Risks and Adaptation Recommendations

5.2.1 Thunderstorms (Lightning)

Thunderstorms are complex meteorological events that can produce high winds, heavy rainfall, hail, and lightning. They pose a variety of risks to mine operations and workers:

- Lightning-induced power surges or electrical interference can damage control systems, data storage devices, and communication networks, which can impact operations and compromise operational efficiency and regulatory compliance requirements.
- Lightning strikes can result in power outages caused by electrical damage to transformers, wires, and transmission line poles
- Lightning is a major health and safety risk to workers working outside at the Project site (e.g., open pits, TMF maintenance). Lightning can impact operations and productivity as workers may need to leave the area for safety reasons.
- A lightning strike on a moving vehicle may introduce other hazards to workers, including:
    - Short-circuiting batteries, tires, and flammable material, resulting in burns.
    - Arc strike causing temporary blindness, resulting in a loss of vehicle control.
    - Failure of electric assisted braking and steering, resulting in a loss of vehicle control.
    - Tire rupture or explosion cause by a substantial increase in tire pressure.
    - If lightning strikes a blast area that has been charged, it can cause the explosives to detonate, which could injure workers nearby or damage neighbouring structures.
- Increased risk of fire to built infrastructure caused by the combustion of wiring, electronics, batteries, fuel, interior furnishings.
- High winds associated with thunderstorms can also pose a safety risk to workers by loose debris and objects becoming high velocity projectiles; these projectiles can also damage buildings and vehicles.

Adaptation strategies to reduce the impacts of thunderstorm related hazards might include the following:

- Have a site-wide electrical grounding system to safely channel electrical power surges away from electrical equipment.
- Install surge protection to protect critical equipment, including computers and sensitive communication equipment.
- Size and install emergency generators to provide power for uninterrupted operation of essential emergency services and equipment to maintain safe operation of the facility. Consider having redundant generators to provide assurance power will be available in the case of a power emergency.

- Develop a health and safety plan/SOP for workers (including on-site contractors and suppliers) to address thunderstorm related risks. As part of the H&S plan/SOP, develop a list of “sturdy” buildings for workers to assemble during thunderstorm activity. A sturdy building is a structure with walls and a foundation that provide protection from lightning, high winds, and other extreme weather events.
- Consider sloped roofs on buildings as they will sustain less direct impact from flying and falling debris and objects than flat roofs. Select impact-resistant roof coverings such as metal or steel roof panels or shingles.

5.2.2 Wildfires

Due to the drier and warmer conditions and the higher chance of lightning under climate change, the risk of wildfire is also expected to increase. A small (<5 ha) wildfire occurred in the proximity of the Project site in June 2023. (Figure A.12)

Wildfire behaviors are unpredictable; the standard defence is having a Fire Management Plan that takes fire behaviour and detection, monitoring, and forecasting into account over the life of the Project. Some adaptation considerations to reduce the risk of wildfire include the following:

- Take action to reduce the availability of combustible materials on and around the Project site. Consider removing trees, branches, grasses, and other combustible materials to create a fire break around the active mine area.
- Implement an operation and maintenance policy to reduce or eliminate potential sources of ignition and fuel immediately around Project buildings, facilities, and active work areas.
- Consider having mobile fire fighting equipment on site to allow quick response to fire risks during the fire season. Provide fire fighting training to workers on the use of the equipment and fire fighting techniques.
- When establishing new ground cover and caps (like at the Impoundment Facility), control the use of non-native invasive plant species that could increase morbidity of native plant species.
- Maintain sufficient levels of water for fire fighting at the Project site. Investigate opportunities to establish on-demand forest fire suppression capabilities and prevention (e.g., use of sprinklers around site).
- Consider implementing a program of prescribed burns around the Project site to remove unwanted vegetation, reducing combustible materials that are more prone to burn during favourable wildfire conditions (e.g., drought or heat waves).
- Remove combustible material along the rail spur right-of-way. Maintain the rail equipment to reduce the rolling stock as a source of ignition for fires.

5.2.3 Inversions

Temperature inversions often develop around sunset, when the air over the open pit walls and floor cools in response to the loss of surface heating from solar radiation. Inversion build-up is facilitated by the flow of cold air down pit slopes to form a pool of cold air over the bottom of the pit, getting trapped by warmer air above. At Project sites, cold air trapped in open pits can result in fog and poor visibility if the air temperature reaches the dew point, impacting ore/waste haulage and drill/blast operations in the pit, creating operational and production delays and increased safety risks to workers. Pollutants from mining equipment and blasting operations can also be trapped near the surface of open pits during an inversion, leading to poor air quality, creating a health and safety risk to workers working in the area.

As inversions occur naturally and cannot be prevented, developing a SOP for working during inversions is recommended and should consider the following:

- Adapt speed limits for haulage trucks and support vehicles when visibility is reduced.
- Have headlights on all Project vehicles that are programmed to be on when the engine is running (daytime running lights), to increase vehicle visibility. While most important during inversions, the use of headlights at all times is highly recommended.
- Install reflective markers/pylons along both sides of haul ramps, to provide visual markers for truck operators during time of low visibility.

6 Conclusions

A CCRA was conducted to identify the climate risks to Project assets and infrastructure. The climate risks were developed for current baseline climate (1981-2010) and for three future climate periods [(2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100)] to assess the risks over the life of the mine.

In addition, risks were calculated for two GHG forcing scenarios or Socio-economic Pathways (SSP), SSP2-4.5 and SPP5-8.5, to assess the change in risks to Project assets and infrastructure under changing GHG concentrations in the atmosphere. While a few of the risks identified were slightly lower under SSP2-4.5, this CCRA focused on the evaluation of risks based on SSP5-8.5, as this pathway closely represents the current trajectory of GHG concentrations in the atmosphere.

The results of the assessment identified a total of 328 risks, with each risk determined by scoring the severity of the climate hazard-infrastructure component interaction using six consequence categories (structural, functional, operations and maintenance, health and safety, environmental and financial) to produce a risk score for each interaction. The greatest number of risks were associated with operations and maintenance impacts to Project assets and infrastructure subcomponents as shown on Figure A.13.

Of the 328 risks, most of the risks were classified as low or moderate, with 95 risks being classified as high. No catastrophic risks were identified. The highest risks were associated with structural impacts from wind to Process Plant buildings and associated equipment such as the primary and secondary crushing, conveyors, and concentrate loadout buildings. Wind gusts were also responsible for high risks related to increase in fugitive dust and dust suppression for pit operations, haulage roads, impoundments and stockpiles, and processing equipment. Other high risks are associated with extreme heat/heat waves causing higher cooling loads on HVAC systems, functional and operation and maintenance impacts to mining equipment, and increased risks of power outages associated with transformer failures.

Extreme heat and heat waves also produced many high risks score (Risks = 10) related to health and safety concerns (potential for heat related illnesses) for workers. These risks should be monitored as an increase in likelihood or severity may carry substantial implications to the well-being of workers and lead to interruptions to mining operations.

Adaptation measures were developed for all moderate and high risks identified for each infrastructure component and are presented in Table 14. The adaptation measures provided are not exhaustive and should be used as a guide to develop further site and infrastructure specific adaptations to reduce the risks caused by the identified climate hazards.

Critical assets such as tailings storage facilities should be actively monitored and inspected, considering the guiding principles in the Global Industry Standards on Tailings Management (GISTM, 2020). This CCRA provides important information about climate and the impacts of climate change, which supports the requirements outlined in Principle 2, Principle 3, and Principle 5 in the GISTM document.

When designing buildings and facilities, Canada Nickel should consider the impacts of climate change by incorporating climate-adjusted design criteria into applicable building codes, so that buildings and major infrastructure are and continue to be resilient to the impacts of extreme weather events and future climate change.

Despite the large number of risks identified, the limited number of high risks (or conversely the large number of low and moderate risks) can be viewed as an indication that Project assets and infrastructure are predicted to be relatively resilient to the impacts of extreme weather and climate change, under current and future climate conditions. Although most of the Project infrastructure may be resilient, given the uncertain trajectory of the greenhouse gas emissions, the climate projections on which the CCRA is based are also highly uncertain. It is recommended this CCRA be considered a baseline document that should be reviewed and updated on a regular basis (initially every five years) as additional climate information and data becomes available, new climate projection models are developed, and current models are updated. The adaptions provided should be considered as recommended guidance to lessen the impacts of the environment on the project over the LOM. They should be reviewed during CCRA updates to ensure they are still relevant, and new adaptations developed to meet changing climate impacts on the Project as required.

Finally, it should be noted that many risks identified in this report can be efficiently and effectively addressed and reduced through O&M policy considerations and the development of SOPs. O&M policies and SOPs should be reviewed and revised on a regular basis over the LOM, so they adequately address current and future impacts to Project assets and workers under a changing climate.

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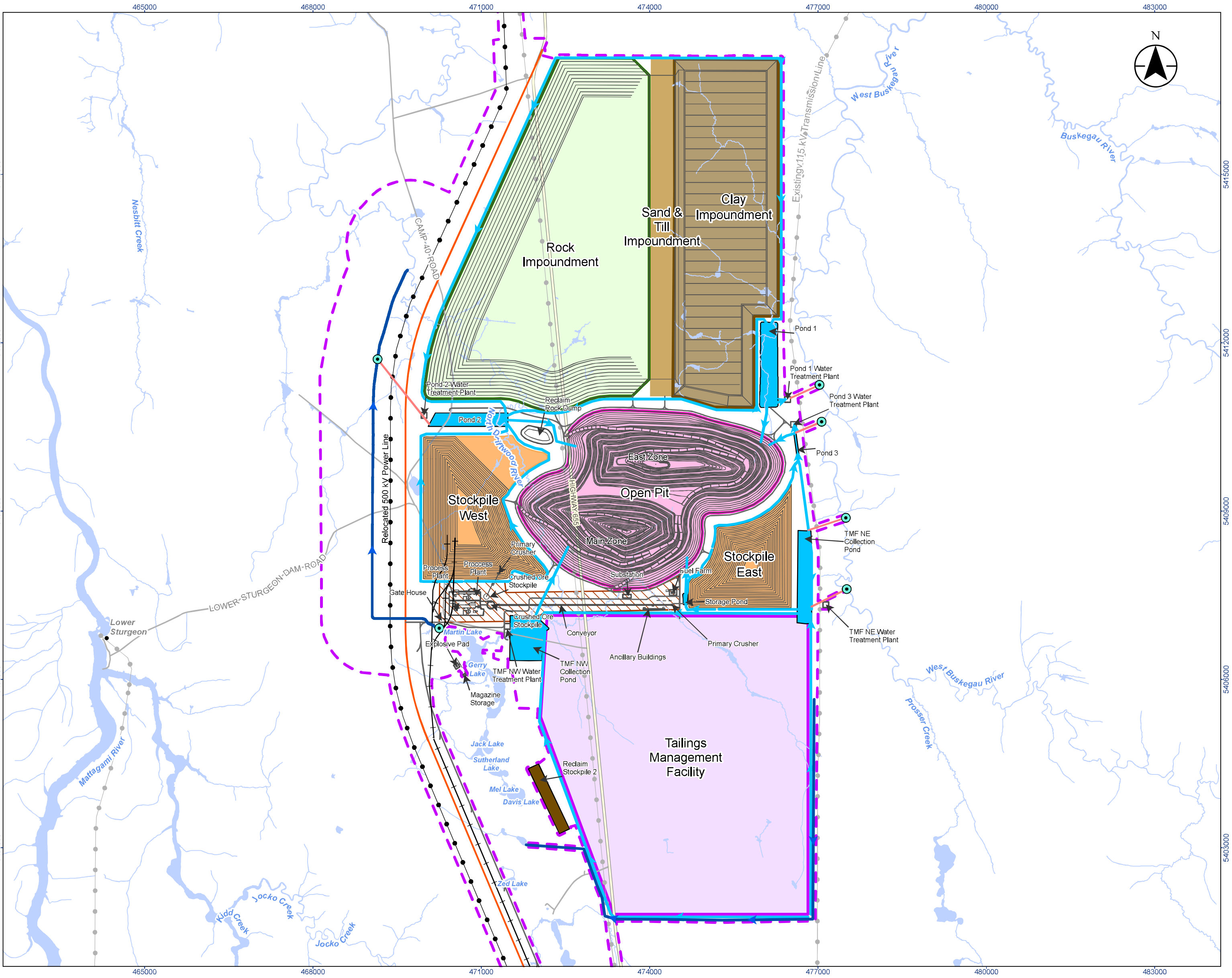
Appendices

Appendix A Figures



Stantec

CANADA NICKEL COMPANY

Legend

▭ Project Area

Base Features

- Existing Major Road
- Existing Minor Road
- Existing Transmission Line
- Watercourse
- Waterbody

Ancilliary Infrastructure

- Relocated Hwy 655
- Rail Spur Line
- Transmission Line

Proposed Project Components

- Discharge Route
- Non-Contact Water Channel
- Contact Water Channel
- Site Road
- Discharge Location
- Ore Stockpile
- Open Pit
- Clay Impoundment
- Pond
- Tailings Management Facility
- Rock Impoundment
- Reclaim Stockpile
- Sand & Till Impoundment
- Process Plant Area

0 1 2 km

1:70,000 (At original document size of 11x17)

Notes

1. Coordinate System:NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © King's Printer for Ontario, 2023.
3. The Project Components and baseline information on this figure are considered preliminary and may be further refined through the development of the Impact Statement based on feedback received from agencies, Indigenous peoples, the public, and project stakeholders.

Project Location
Timmins, Ontario

160930456 REVA
Prepared by tcoghlan on 2024-09-10

Client/Project
Canada Nickel Company (CNC)
Crawford Nickel Project

Figure No.
A.1

Title
Project Site Plan - Mine Site

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\\cd1004-f01\01609\active\160930456\gis_cad\gis\mxds\IS\TDR\160930456_IS-TDR_Climate.aprx\160930456_IS-TDR_Climate_FigA.1_MineSite Revised: 2024-09-10 By: tcoghlan

Figure A.2 Steps in a Climate Change Resilience Assessment

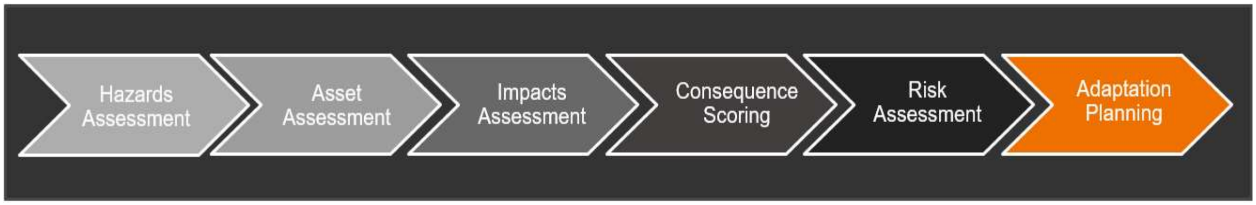


Figure A.3 Physical Climate Change Resilience Assessment (CCRA) Process

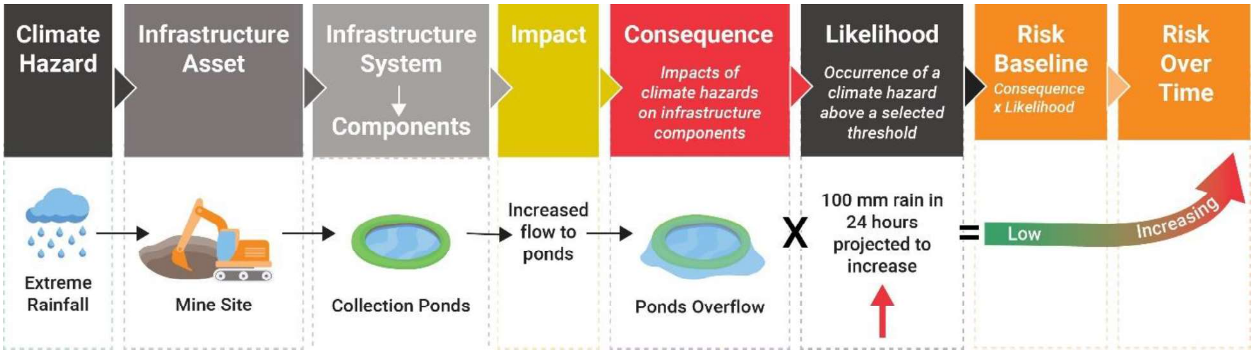


Figure A.4 Historical and projected CO_2 emissions trajectories for five Shared Socio-economic Pathways (Riahi et al. 2016)

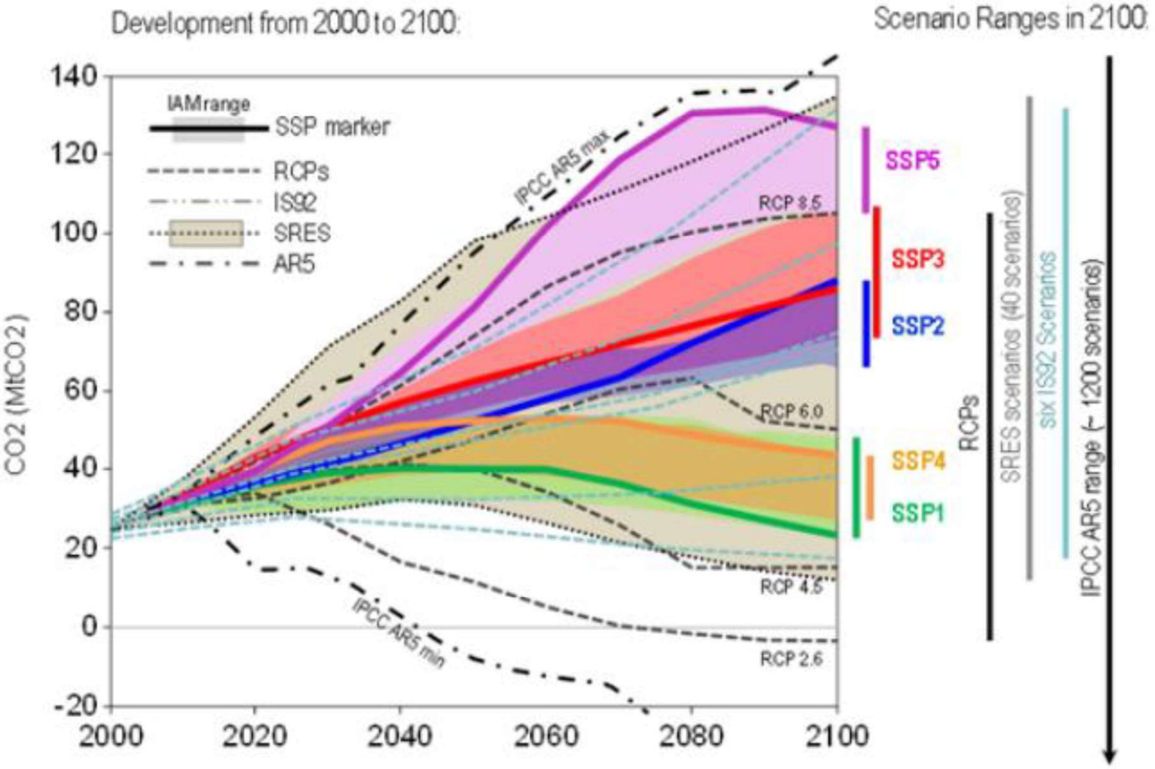


Figure A.5 Local Historical Weather Stations for Crawford Nickel Project

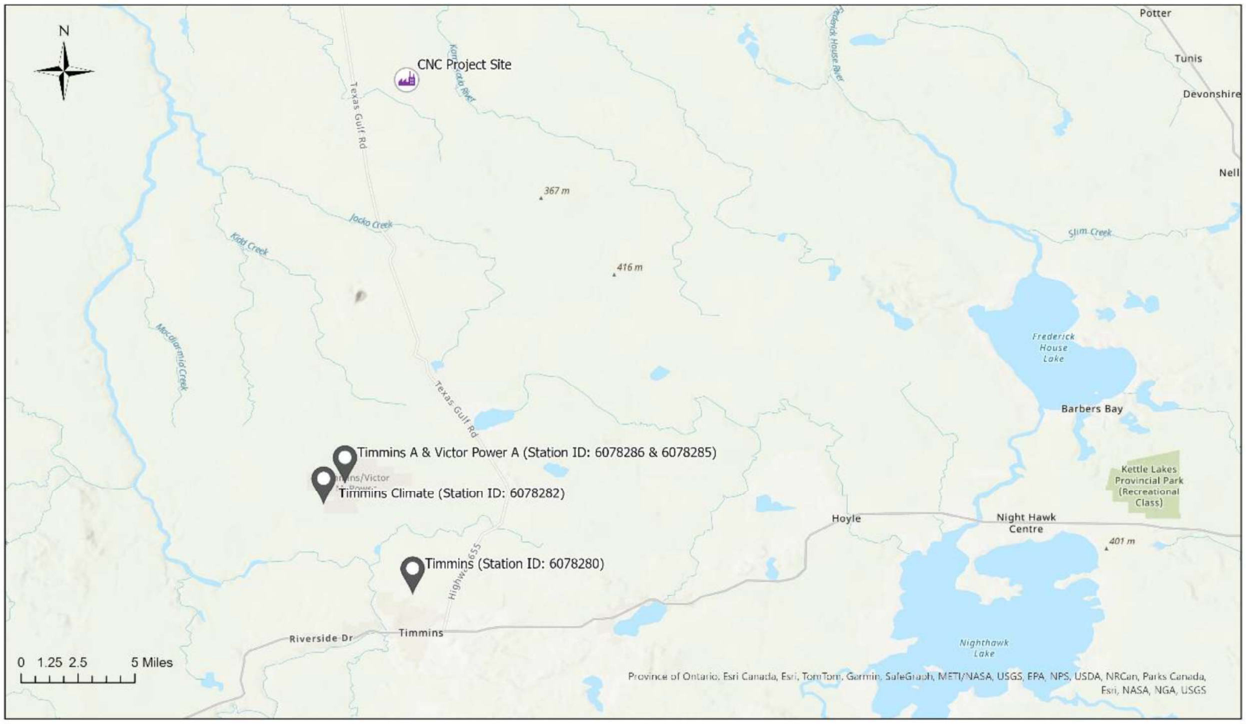


Figure A.6 Total Risks and Breakdown by Consequence Category

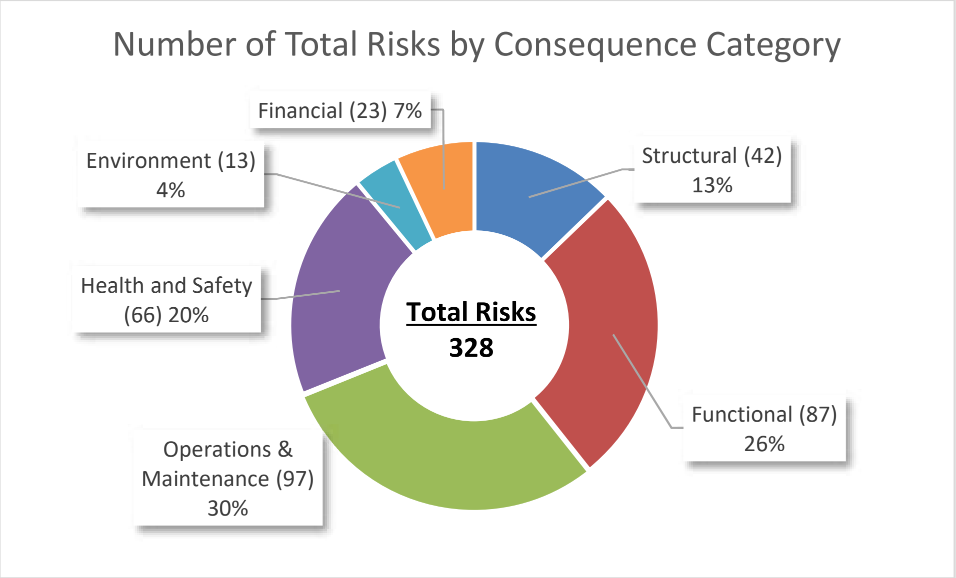


Figure A.7 Total Risks by Infrastructure Category

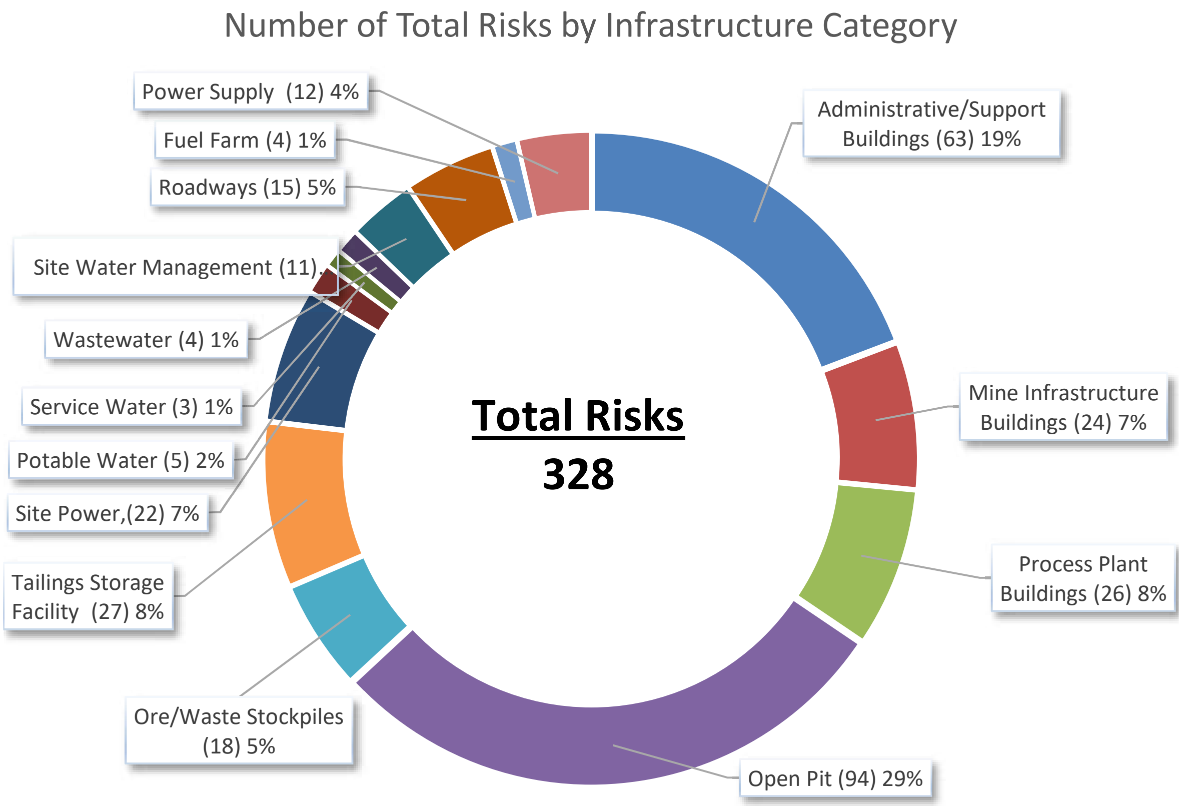


Figure A.8 Distribution of Risks by Climate Hazard

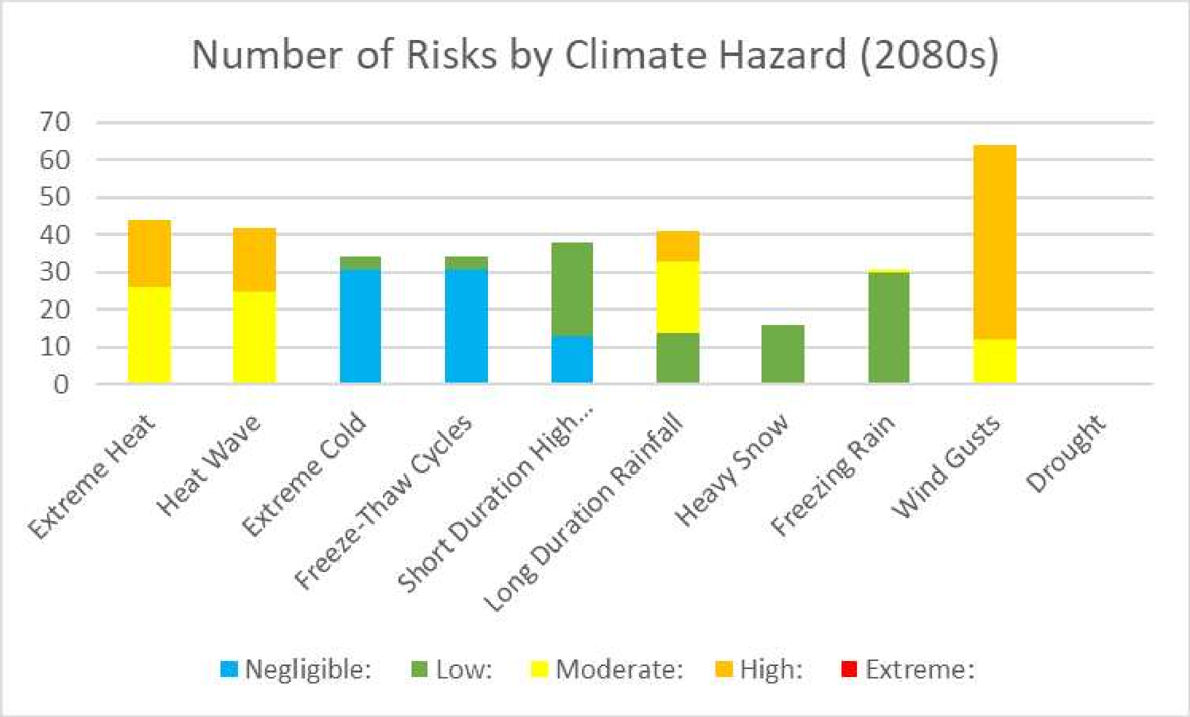


Figure A.9 Distribution of Risks by Time Horizon

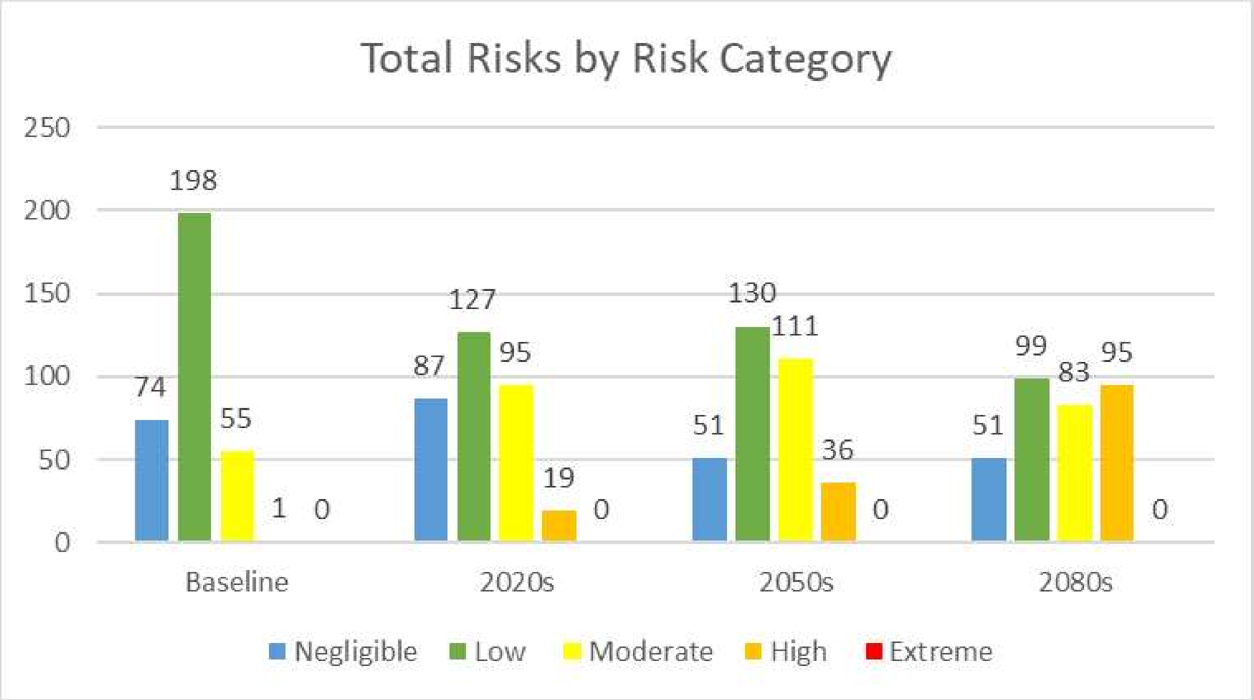


Figure A.10 Number of Risks by Climate Hazard for SSP2-4.5 and SSP5-8.5 Pathways

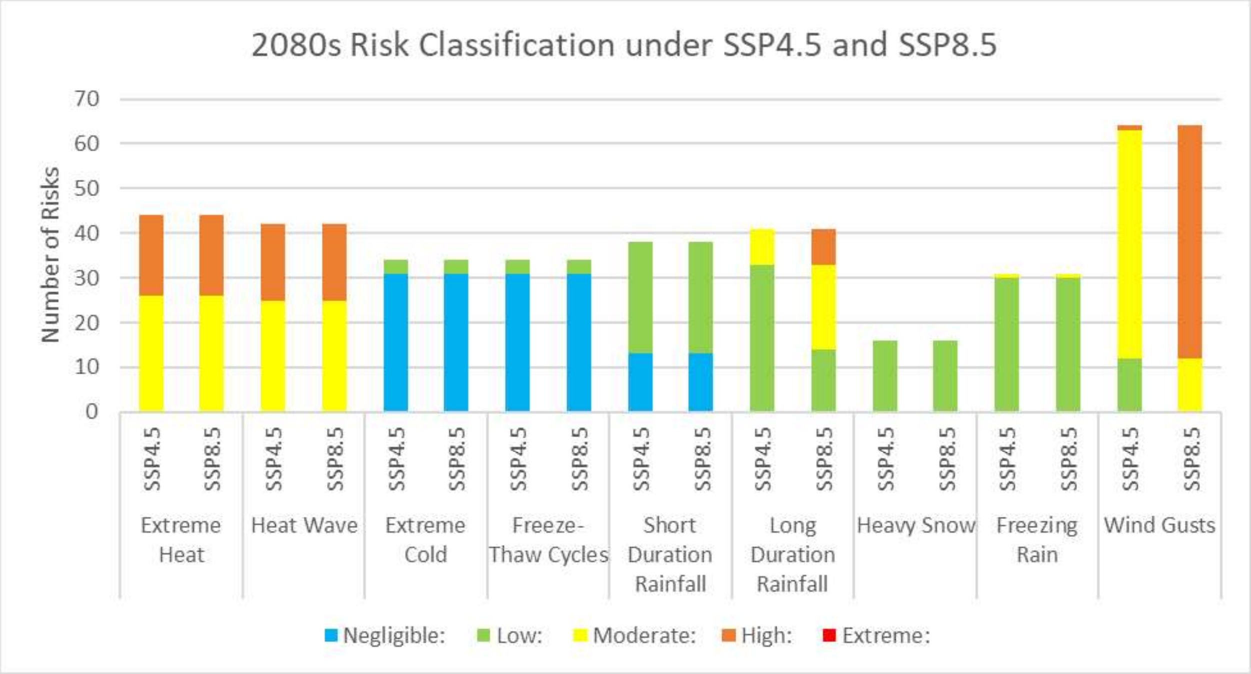


Figure A.11 Adaptation and Mitigation for a Wholistic Climate Based Solution (CVRD 2021)

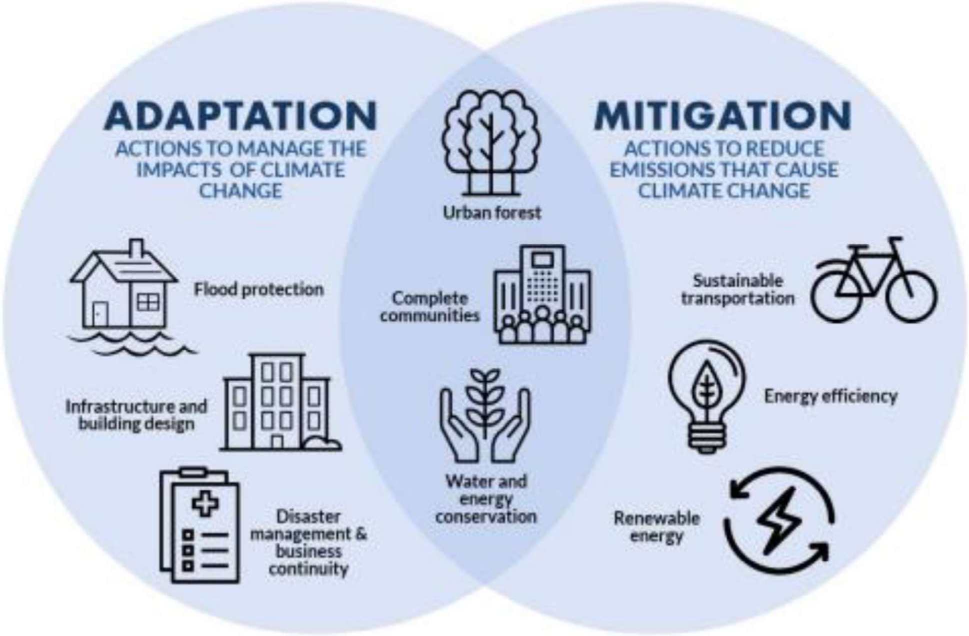


Figure A.12 Location of Cochrane 009 Fire

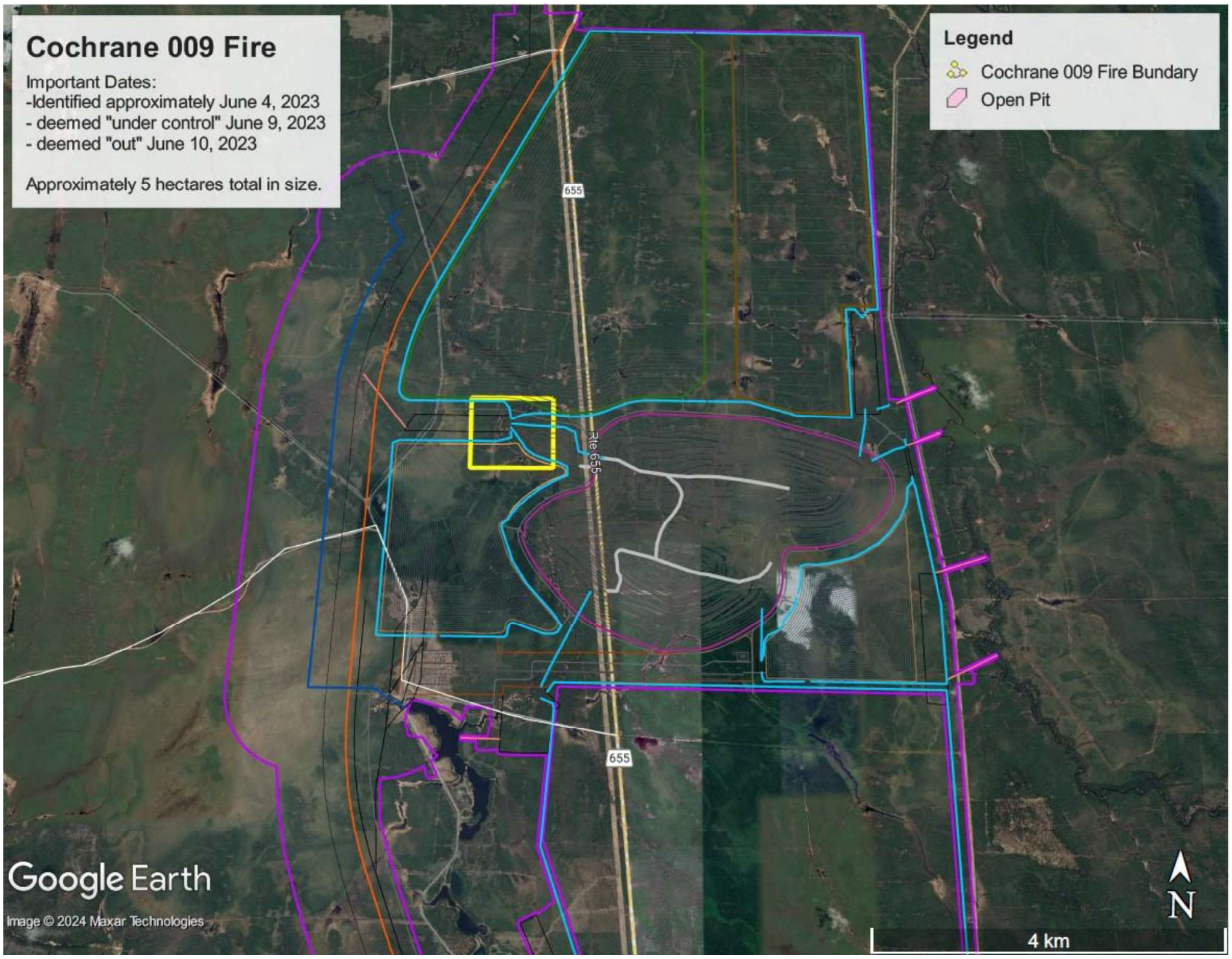
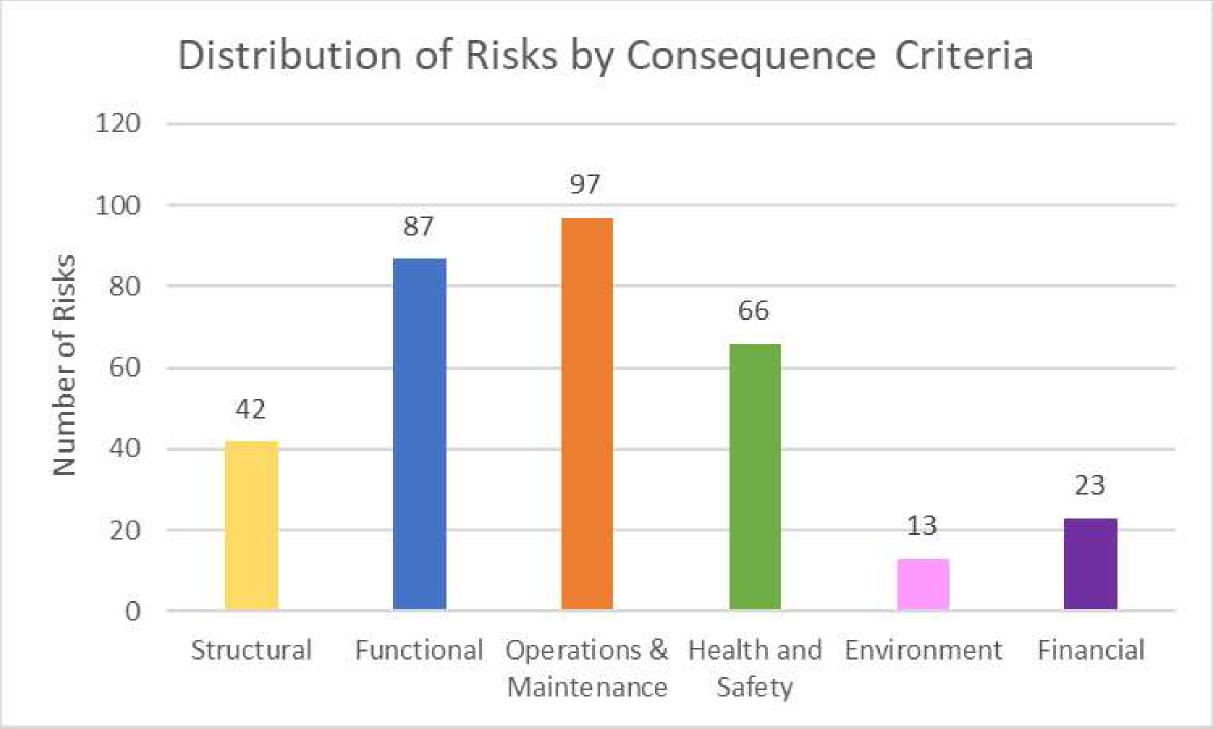


Figure A.13 Distribution of Risks by Consequence Score



Appendix B Climate Profile – Crawford Nickel Project

Crawford Nickel Project: Climate Profile

September 30, 2024

Prepared for:

Canada Nickel Company

Prepared by:

Stantec Consulting Ltd.

Table of Contents

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List of Abbreviations

°	degrees (temperature)
AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
C	Celsius
CanDCS-U6	Canadian Downscaled Climate Scenario – Univariate
C-C	Clausius-Clapeyron
CCRA	Climate Change Risk Assessment
CDD	Cooling Degree Days
cm	centimetres
CMIP5	Fifth Coupled Model Intercomparison Project
CMIP6	Sixth Coupled Model Intercomparison Project
CO^2	Carbon Dioxide
CSA	Canadian Standards Association
ECCC	Environment and Climate Change Canada
EF-Scale	enhanced Fujita scale
F-Scale	Fujita scale
GCM	Global Climate Model
GHG	Greenhouse Gas
Gt CO^2	Global Carbon Dioxide Emissions
ha	hectares
HDD	Heating Degree Days

hr	hours
IAAC	Impact Assessment Agency of Canada
IDF	Intensity-Duration-Frequency
IPCC	Intergovernmental Panel on Climate Change
km	kilometres
kph	kilometres per hour
m	metres
min	minutes
mm	millimetres
NRCan	Natural Resources Canada
PA	Project Area
RCP	Representative Concentration Pathways
SPEI	Standardized Precipitation Evapotranspiration Index
SSPs	Shared Socio-Economic Pathways
TIS Guidelines	Tailored Impact Statement Guidelines
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

1 Introduction

Canada Nickel Company (Canada Nickel) proposes to develop, operate, and progressively reclaim the Crawford Nickel Project (the "Project"), a new open pit nickel mine and processing facility approximately 42 kilometres (km) north of Timmins, Ontario along Highway 655. Stantec Consulting Ltd. (Stantec) has been retained by Canada Nickel to conduct a Climate Change Risk Assessment (CCRA) pursuant to the *Impact Assessment Act, 2019* and in consideration of the Tailored Impact Statement Guidelines: Crawford Nickel Project (Impact Assessment Agency of Canada [IAAC] 2023) (TIS Guidelines). The intent of the CCRA is to identify current and future climate-related risks to the Project assets, infrastructure, and operations, and develop climate adaptation and resilience measures that can be considered by Canada Nickel to limit the physical impacts of climate change during the life of the mine, including mine construction and development, operations, through to mine decommissioning and closure activities.

This climate profile summaries the climate baseline and future climate projections for the Project Area (PA). The information was obtained from publicly available federal and provincial resources for hydrological, climate, physiographic data, local weather and climate monitoring programs and global climate models (GCMs).

1.1 Description of Climate Profiles

Climate is usually defined as the "average weather," or more rigorously, as the statistical description of the mean and variability of meteorological variables such as temperature, precipitation, and wind over a period of time. Climate profiles are important tools that describe what climate trends and conditions have been occurring in recent history (i.e., over the last 30 years or longer), and describe future climate conditions to help inform the planners, stakeholders, and decision makers to manage climate change risks and plan for the appropriate adaptation measures.

Climate profiles rely on the historical climate record (usually in the form of meteorological data measured at weather stations) to describe climate from recent history and on climate projections (developed by GCMs). The historical climate profile puts future climate projections into context: the performance of the infrastructure from the past can be compared to both historical and future climate to better understand what (if any) adaptation measures should be implemented to improve performance and resilience in the future.

When developing a profile of the historical climate of an area, the most valuable data is typically temperature, precipitation, and wind. Meteorological data from the last 30 years is preferred to help give a representative estimate of the climate of recent history at a given location – though longer periods are of benefit in that they add more to the story of an area's historical climate. Environment and Climate Change Canada (ECCC) provides the largest database of observational historical climate data in Canada. In addition to assembled climate data from weather stations, gridded data products are available and provide additional climate data resources. These gridded data products include the NRCan-met gridded dataset, produced by Natural Resources Canada (NRCan), which provides daily maximum and minimum temperature and total precipitation data on a ~10 km grid resolution over Canada for the 1950-2013 time period (Hopkinson 2011) (McKenney 2011.). Although observational data from a weather station is preferable, gridded datasets such as NRCan-met are well accepted and researched. While not a directly measured data set, NRCan-met is a peer-reviewed, gridded interpolation of the daily weather conditions and historical climate for land-based locations in Canada. As such, the NRCan-met datasets can provide reasonable approximations for locations when historical observational data is inadequate for a climate assessment.

Climate projections are descriptions of the future climate and are most often collected from GCMs developed by many organizations around the world. GCMs are complex; they rely on many different assumptions on Earth’s climate and on the future (i.e., they focus on different physical phenomena to estimate future climate, whether it be greenhouse gas (GHG) concentrations in the atmosphere or absorption of solar radiation by the ocean). There are nearly 40 GCMs that have contributed to the Sixth Coupled Model Intercomparison Project (CMIP6), which forms the basis of many of the latest publications from the Intergovernmental Panel on Climate Change (IPCC). Since different GCMs focus on different physical phenomena, there is a noticeable difference in the future climate that is predicted. Therefore, it is not recommended to rely only on one or two of these GCMs to estimate future climate. Instead, an average of multiple GCMs, known as an ensemble, tends to give a more reliable estimate of future climate. The Canadian Downscaled Climate Scenario – Univariate (CMIP6) (CanDCS-U6) has taken a subset of 26 of these models to produce reliable, high-resolution downscaled climate projections localized to specific areas of interest in Canada (Pacific Climate Impacts Consortium and University of Victoria 2021).

The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

In addition to the physics of the GCMs, global progress towards meeting GHG emissions targets is also a large source of uncertainty in future climate projections. There are five shared socio-economic pathways (SSPs)[1] adopted by the IPCC that are based on various future GHG scenarios and socio-economic assumptions. This climate profile focuses on the medium and high GHG concentrations scenario, SSP2-4.5 and SSP5-8.5.

Most climate variables identified in this profile will be assessed using CMIP6 SSP2-4.5 and SSP5-8.5 scenarios. However, due to the recent release of the CMIP6 climate models, not all relevant climate variables in this profile are simulated. Therefore, the CMIP5 RCP (representative concentration pathways) 4.5 and RCP8.5 climate change scenarios are selected to fill in

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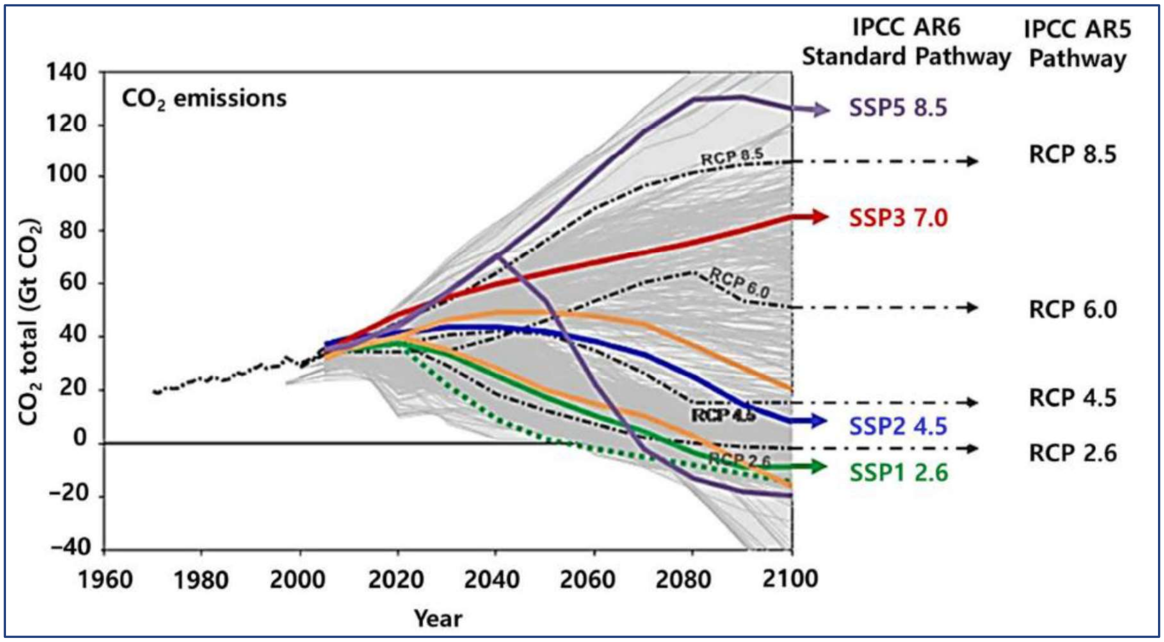
[1] SSP: Shared Socio-economic Pathways – greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its sixth Assessment Report (AR6) in 2020.

the data gaps. Figure 1 shows predicted global GHG concentration pathways under different climate change scenarios using all GCMs.

Figure 1 SSP-RCP Scenario Pathways out to 2100 based on all GCMs[2] (Riahi, et al. 2017)



1.2 Climate Profile for the Project

A climate profile was required for the Project to assess the risks and environmental impacts from climate change and extreme weather events. The climate profile for the Project required a review of available historical observed weather data and climate projection data for the region. The historical climate for the PA is based on observations from local ECCC weather stations in the City of Timmins as shown on Figure 2. The weather stations in the Timmins region are the nearest stations to the PA with historical data availability, so were used to develop the Project climate profile.

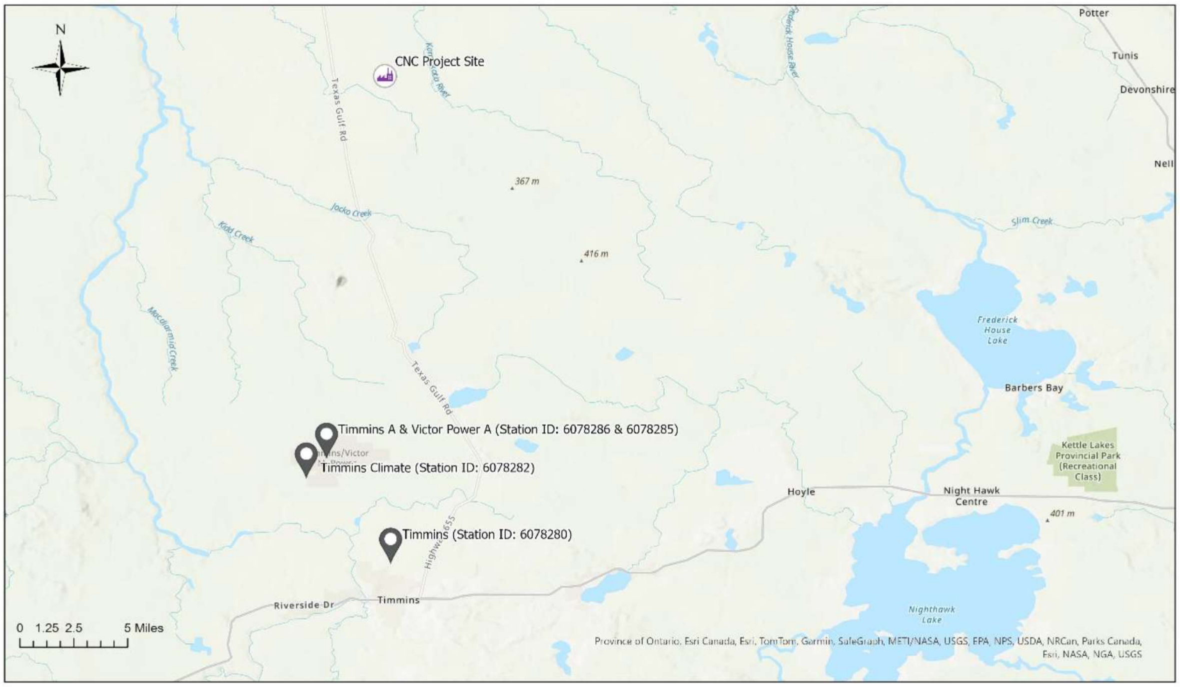
There are four ECCC weather stations for Timmins that provide data in hourly to daily time steps. A summary of the weather station data with the most complete historical datasets is shown in Table 1. The stations used in this profile are Timmins (Station ID: 6078280), Timmins A (Station ID: 6078286), Timmins Victor Power A (Station ID: 6078285) and Timmins Climate (Station ID: 6078282).

---

[2] Each full/dashed line represent an SSP/RCP scenario and their respective arrows beyond 2100 indicate their scenario name and do not represent modelled data. Additionally, the purple line (SSP5) diverges into 2 scenarios after 2040. The upper purple line follows the SSP5-8.5 path with no significant change in policy, while the lower purple follows the SSP5-3.4OS path that represents an overshoot scenario with a large emphasis on carbon capture technology after 2040.

Data from the four stations have been used to obtain complete datasets for temperature, precipitation, snow and wind, which results in a climate data records for the periods 1981-2010 and 1991-2020. For all missing temperature and precipitation data between 1950 and 2010, the NRCAN-met gridded dataset was used to fill the gaps.

Figure 2 Local Historical Weather Stations



Province of Ontario, Esri Canada, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, NRCan, Parks Canada, Esri, NASA, NGA, USGS

The time periods of 1981-2010 and 1991-2020 were selected as current conditions for the Project establishing the climate baseline. The climate for the 2020s (time horizon of 2011 to 2040) is presented to evaluate how recent trends correlate with near-future projections. The 2050s (2041 to 2070) and 2080s (2071 to 2100) time horizons are presented as longer-term climate projections, which will highlight the variation between the various future GHG scenarios presented to help inform the stakeholders and decision-makers of the climate risks to the infrastructure in the region. The projected climate values represent the projected average over a 30-year time period in the future.

Table 1 Summary of Weather Monitoring Stations in the Timmins Region

Weather Monitoring Station	Latitude	Longitude	Data Source [Time Step]	Data Range[3] [% of Data Available]	Elevation	Distance to Asset Location
Timmins	48°30’00.000 N	81°20’00.000 W	ECCC (6078280) [Daily]	1950-1957 [Temperature 94.5% Precipitation 81.2% Wind 0.0% Snow 82.0%]	335.3 m	~36.42 km
Timmins A	48°34’14.000 N	81°22’36.000 W	ECCC (6078286) [Daily and Hourly]	2012-2024 [Temperature 98.4% Precipitation 17.9% Wind 84.5% Snow 19.6%]	294.7 m	~28.70 km
Timmins Victor Power A	48°34’11.000 N	81°22’36.000 W	ECCC (6078285) [Daily and Hourly]	1955-2012 [Temperature 99.2% Precipitation 94.6% Wind 97.5% Snow 94.6%]	294.7 m	~28.79 km
Timmins Climate	48°33’26.000 N	81°23’25.000 W	ECCC (6078282) [Daily and Hourly]	2008-2024 [Temperature 96.3% Precipitation 95.2% Wind 83.1% Snow 0.0%]	294.4 m	~30.28 km

---

2 Temperature

2.1 Mean Temperature

2.1.1 Annual and Seasonal Average

Summaries of mean historical temperature and average change in mean temperature from the baseline climate for the Timmins region are shown in Table 2. Annual and seasonal temporal averages for daily mean temperature in the Timmins region are shown on Figure 3 and the annual mean temperature trend and future 30-year projection averages are shown on Figure 4. Annual and seasonal mean temperature is projected to increase from the 1981-2010 baseline with the greatest seasonal changes (+5.2°C and +8.4°C) occurring in the winter months under SSP2-4.5 and SSP5-8.5, respectively.

Table 2 Historical and Projected Mean Temperature

Season	Mean Temperature 1981-2010 (°C)	Mean Temperature 1991-2020 (°C)	Average (Change in) Mean Temperature from 1981-2010 Baseline (°C)					
			2020s		2050s		2080s	
			SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Annual	1.8	1.9	3.3 (+1.5)	3.4 (+1.6)	4.7 (+2.9)	5.8 (+4.0)	5.9 (+4.1)	8.6 (+6.8)
Winter	-14.3	-14.0	-12.4 (+1.9)	-12.2 (+2.1)	-10.6 (+3.7)	-9.2 (+5.1)	-9.1 (+5.2)	-5.9 (+8.4)
Spring	1.3	1.0	2.7 (+1.4)	2.7 (+1.4)	4.0 (+2.7)	4.8 (+3.5)	4.9 (+3.6)	7.6 (+6.3)
Summer	16.1	16.4	17.5 (+1.4)	17.6 (+1.5)	18.8 (+2.7)	19.7 (+3.6)	19.8 (+3.7)	22.4 (+6.3)
Autumn	4.0	4.3	5.5 (+1.5)	5.6 (+1.6)	6.8 (+2.8)	7.7 (+3.7)	7.7 (+3.7)	10.5 (+6.5)

Figure 3 Historical and Projected Mean Temperature

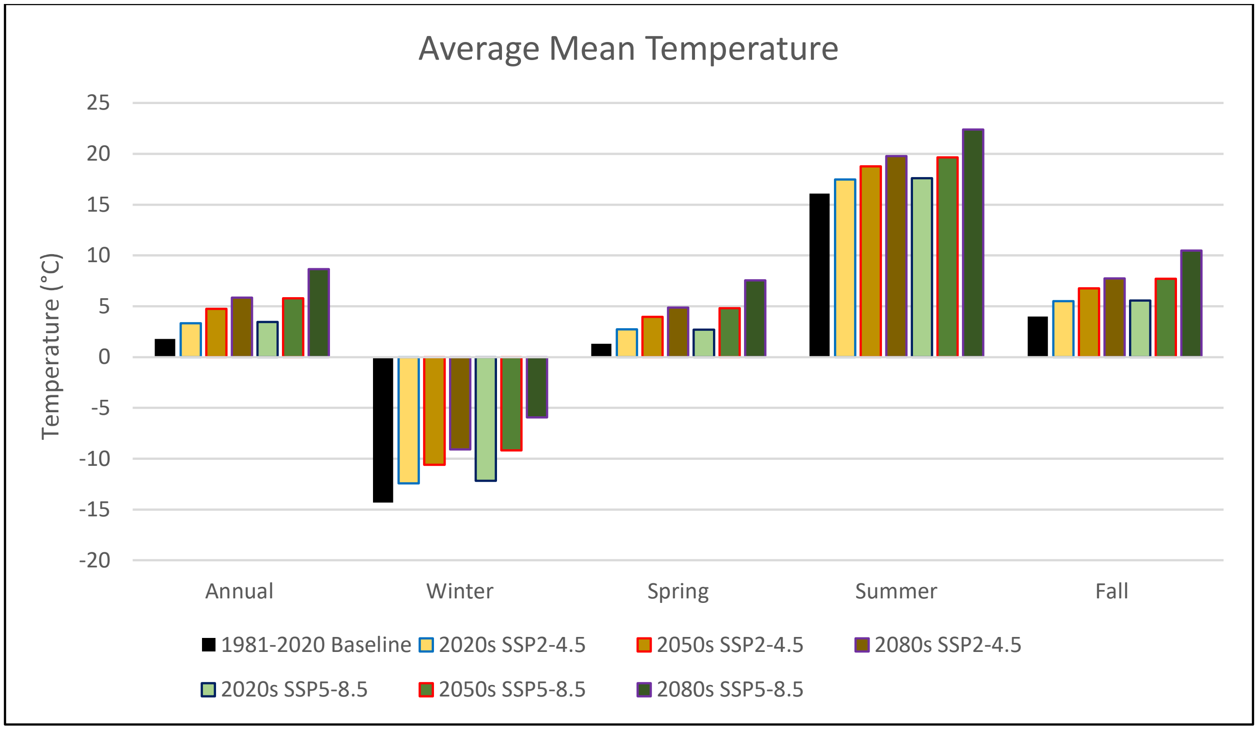
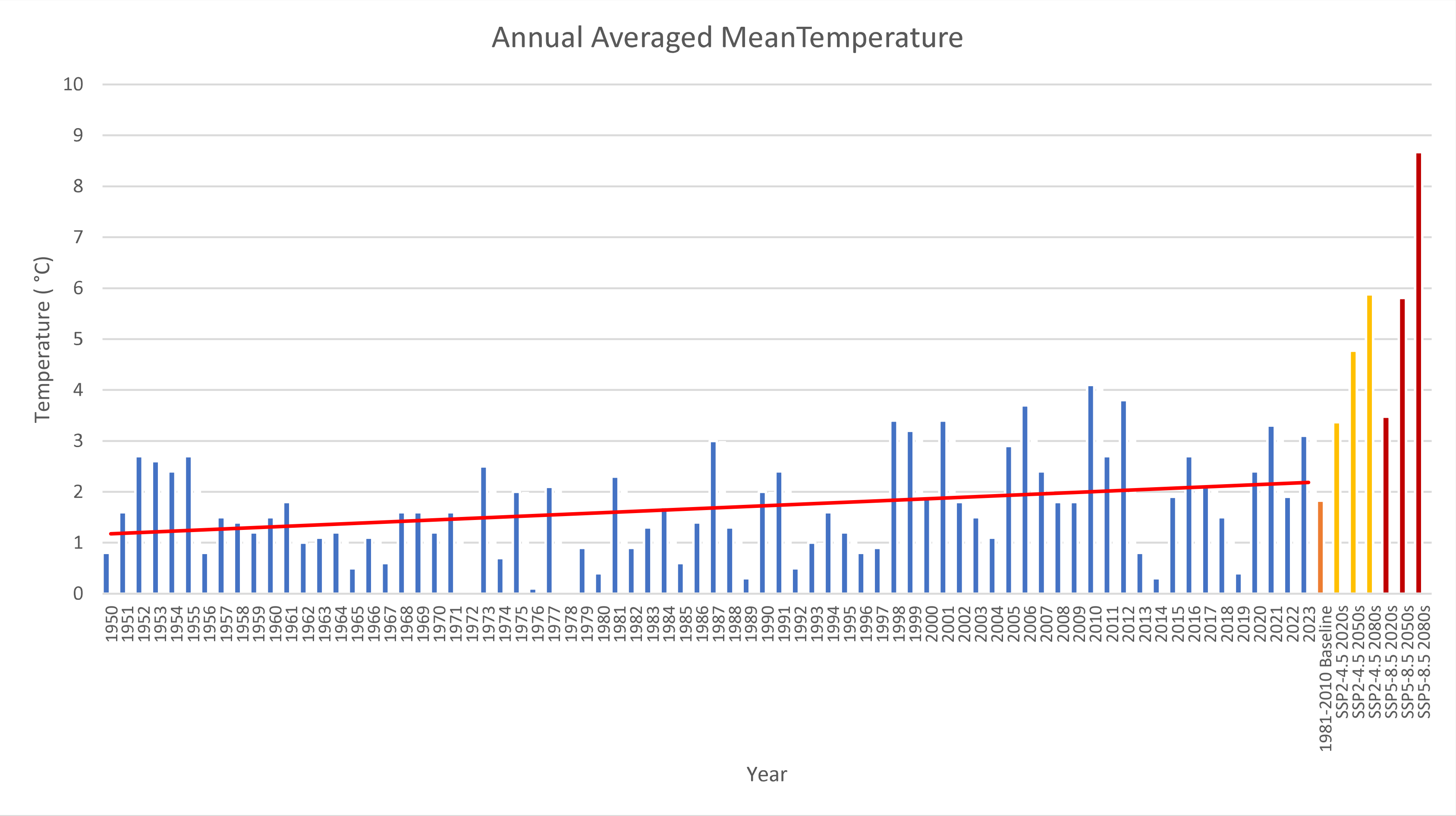


Figure 4 Annual and Projected Mean Temperature Averages



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2.2 Maximum Temperature

2.2.1 Annual and Seasonal Average

Maximum historical temperatures averaged from the baseline period of 1981-2010 and 1991-2020 and average change in maximum temperature from the baseline are shown in Table 3. Annual and seasonal temporal averages for daily maximum temperature in the region are shown on Figure 5 and the annual maximum temperature trend and future 30 year projection averages are shown on Figure 6. The maximum annual and seasonal temperatures are projected to increase from the 1981-2010 baseline with the greatest seasonal increase occurring in the winter months (+4.3°C and +6.9°C) under SSP2-4.5 and SSP5-8.5, respectively.

Table 3 Historical and Projected Maximum Temperature in Timmins

Season	Maximum Temperature 1981-2010 (°C)	Maximum Temperature 1991-2020 (°C)	Average (Change in) Maximum Temperature from 1981-2010 Baseline (°C)					
			2020s		2050s		2080s	
			SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Annual	7.9	8.0	9.4 (+1.5)	9.5 (+1.6)	10.7 (+2.8)	11.7 (+3.8)	11.8 (+3.9)	14.4 (+6.5)
Winter	-8.2	-8.2	-6.6 (+1.6)	-6.4 (+1.8)	-5.1 (+3.1)	-4.0 (+4.2)	-3.9 (+4.3)	-1.3 (+6.9)
Spring	8.0	7.8	9.4 (+1.4)	9.4 (+1.4)	10.6 (+2.6)	11.4 (+3.4)	11.4 (+3.4)	14.0 (+6.0)
Summer	22.9	23.2	24.4 (+1.5)	24.5 (+1.6)	25.7 (+2.8)	26.7 (+3.8)	26.8 (+3.9)	29.5 (+6.6)
Autumn	8.9	9.2	10.5 (+1.6)	10.5 (+1.6)	11.7 (+2.8)	12.7 (+3.8)	12.7 (+3.8)	15.5 (+6.6)

Figure 5 Historical and Projected Maximum Temperature

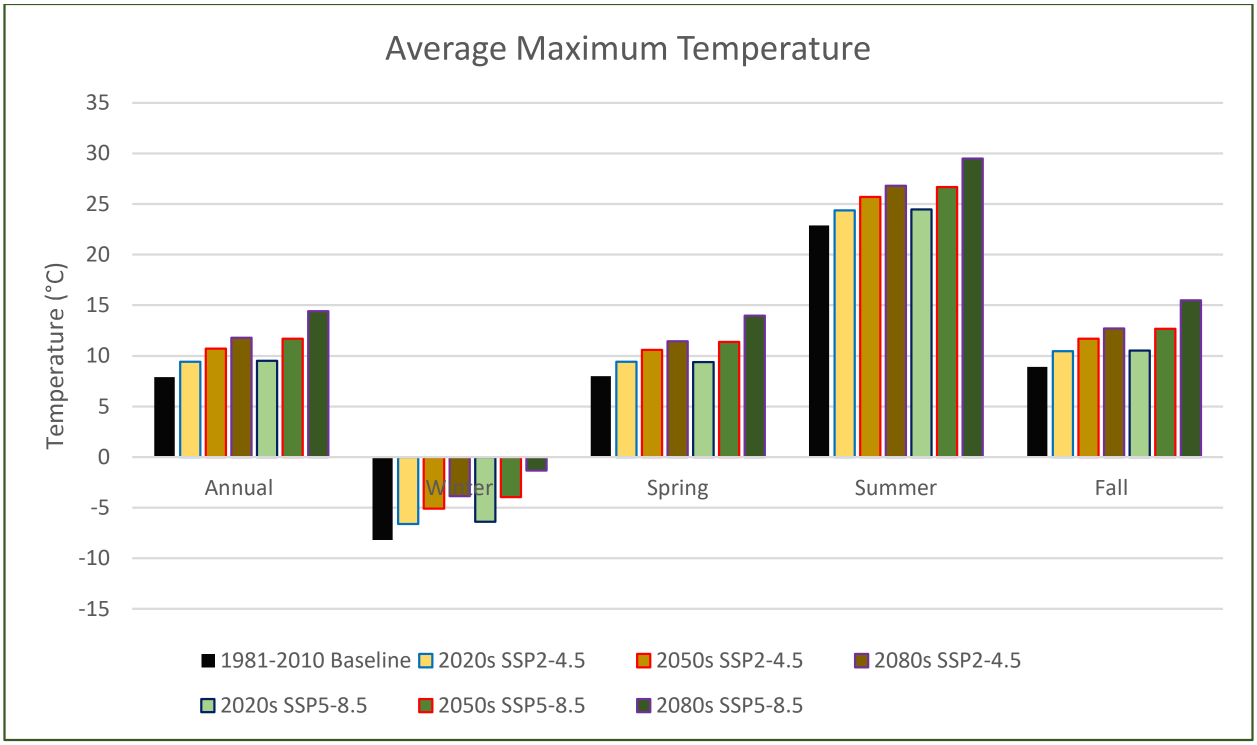
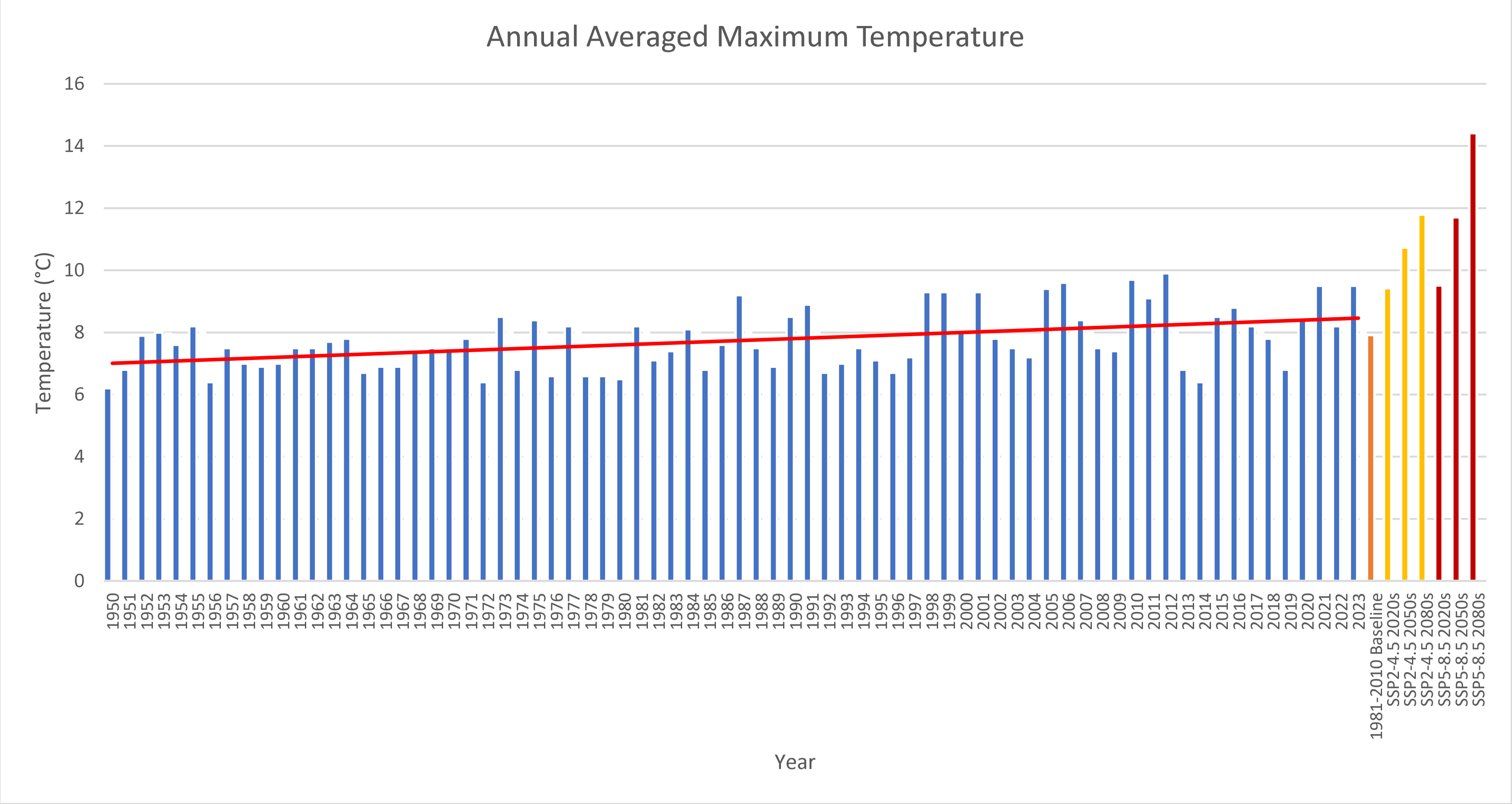


Figure 6 Annual and Projected Daily Maximum Temperature Averages



2.2.2 Extreme Maximum Temperature Frequency

Extreme heat can negatively affect some infrastructure. Thermal expansion caused by excessive heating can accelerate material degradation, impacting structural integrity and increasing operational and maintenance needs. The average number of days with daily maximum temperatures greater than or equal to 30°C, 32°C and 35°C in the Timmins region is shown in Table 4. The frequency of extreme high temperatures is projected to increase for the region under climate change.

Table 4 Summary of Historical and Projected Number of Days per Year with Maximum Daily Temperature ≥30°C, 32°C, and 35°C

Average Annual Number of Days with Max. Temp ≥ 30°C							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
7.5	8.5	15.1	15.7	23.8	31.2	31.9	55.7
Average Annual Number of Days with Max. Temp ≥ 32°C							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
3.1	2.9	6.4	6.8	12.0	18.1	18.2	38.4
Average Annual Number of Days with Max. Temp ≥ 35°C							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
0.3	0.3	1.4	1.5	3.3	5.9	5.8	18.6

2.2.3 Heatwaves

A heat wave event is defined as three or more consecutive days above a daily maximum temperature threshold. For the Timmins region, heat wave thresholds of 30°C or greater and 35°C or greater have been assessed. The frequency of heat waves and average annual number of days in a heat wave (Table 5) are projected to increase for the Timmins region.

Table 5 Average Annual Number of Heat Waves and Days in Heat Waves

Average Annual Number of Heat Waves (30°C or greater)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
0.03	0.03	0.4	0.5	1.0	1.7	1.7	4.1
Average Annual Number of Days in a Heat Wave (30°C or greater)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
0.1	0.1	1.5	1.7	4.2	7.5	7.4	23.9
Average Annual Number of Heat Waves (35°C or greater)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
0.0	0.0	0.1	0.1	0.3	0.5	0.5	2.1
Average Annual Number of Days in a Heat Wave (35°C or greater)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
0.0	0.0	0.3	0.3	1.0	2.2	2.0	10.8

2.2.4 Cooling Degree Days

Cooling Degree Days (CDD) are equal to the number of degrees Celsius a given day’s mean temperature is above 18°C. For example, if the daily mean temperature is 21°C, the CDD value for that day is equal to 3°C. CDD are totaled over a time period (e.g., monthly, seasonally, or annually).

CDD provide an indication of the cooling capacity required to maintain comfortable building conditions during warmer months. The historic and projected CDD for the Timmins region are provided in Table 6. The number of annual CCD is expected to increase under SSP2-4.5 and SSP-5-8.5.

Table 6 Average Annual Cooling Degree Days

Average Annual Cooling Degree Days (CDD)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
95.6	100.7	185.2	192.9	269.5	341.9	346.6	607.8

2.3 Minimum Temperature

2.3.1 Annual and Seasonal Average

Minimum historical temperature average from the baseline periods of 1981-2010 and 1991-2020 and average change in minimum temperature from the baseline for the Timmins area are shown in Table 7. Annual and seasonal temporal averages for daily minimum temperature are shown on Figure 7 and the annual minimum temperature trend and future 30 year projection averages are shown on Figure 8. The minimum annual and seasonal temperatures are projected to increase from the 1981-2010 baseline with the greatest seasonal increase (+6.1°C and +9.9°C) occurring in the winter months under SSP2-4.5 and SSP5-8.5, respectively.

Table 7 Historical and Projected Minimum Temperature

Season	Minimum Temperature 1981-2010 (°C)	Minimum Temperature 1991-2020 (°C)	Average (Change in) Minimum Temperature from 1981-2010 Baseline (°C)					
			2020s		2050s		2080s	
			SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Annual	-4.3	-4.1	-2.7 (+1.6)	-2.6 (+1.7)	-1.2 (+3.1)	-0.1 (+4.2)	-0.1 (+4.2)	2.9 (+7.2)
Winter	-20.2	-19.7	-18.0 (+2.2)	-17.7 (+2.5)	-15.9 (+4.3)	-14.2 (+6.0)	-14.1 (+6.1)	-10.3 (+9.9)
Spring	-5.4	-5.7	-4.0 (+1.4)	-4.0 (+1.4)	-2.7 (+2.7)	-1.7 (+3.7)	-1.7 (+3.7)	1.2 (+6.6)
Summer	9.3	9.4	10.6 (+1.3)	10.7 (+1.4)	11.8 (+2.5)	12.6 (+3.3)	12.8 (+3.5)	15.3 (+6.0)
Autumn	-0.8	-0.6	0.7 (+1.5)	0.7 (+1.5)	1.9 (+2.7)	2.8 (+3.6)	2.9 (+3.7)	5.6 (+6.4)

Figure 7 Historical and Projected Minimum Temperature

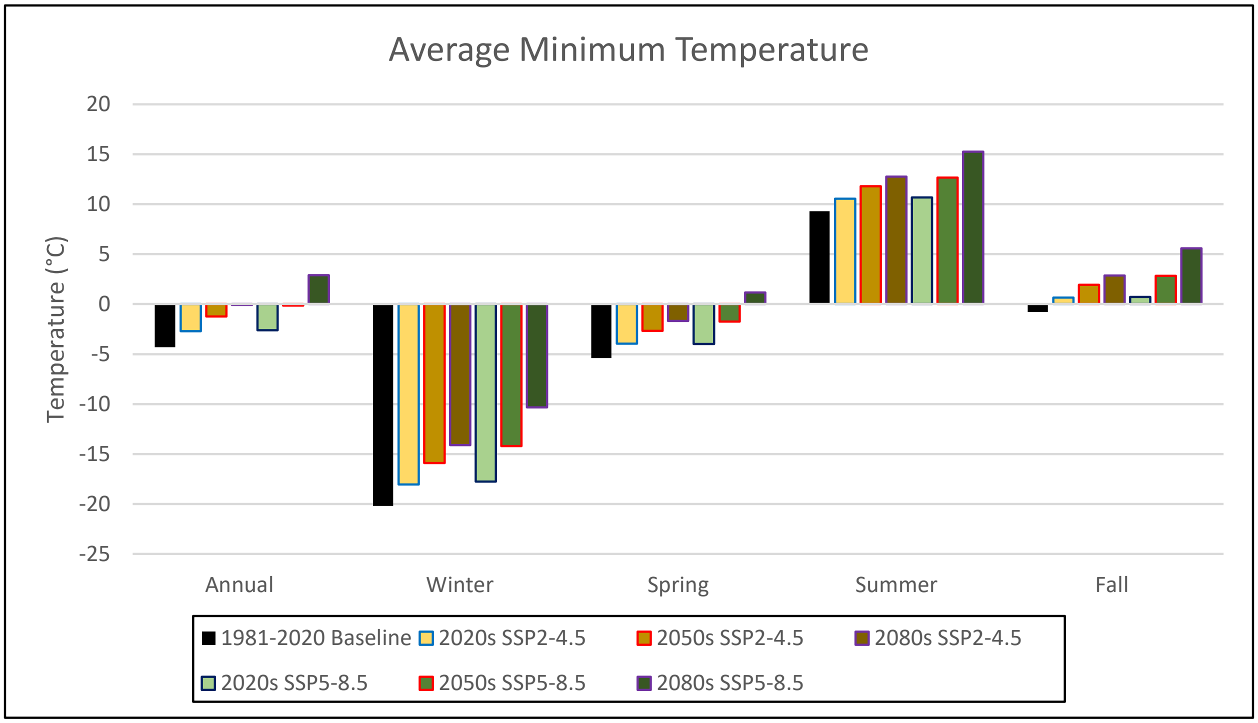
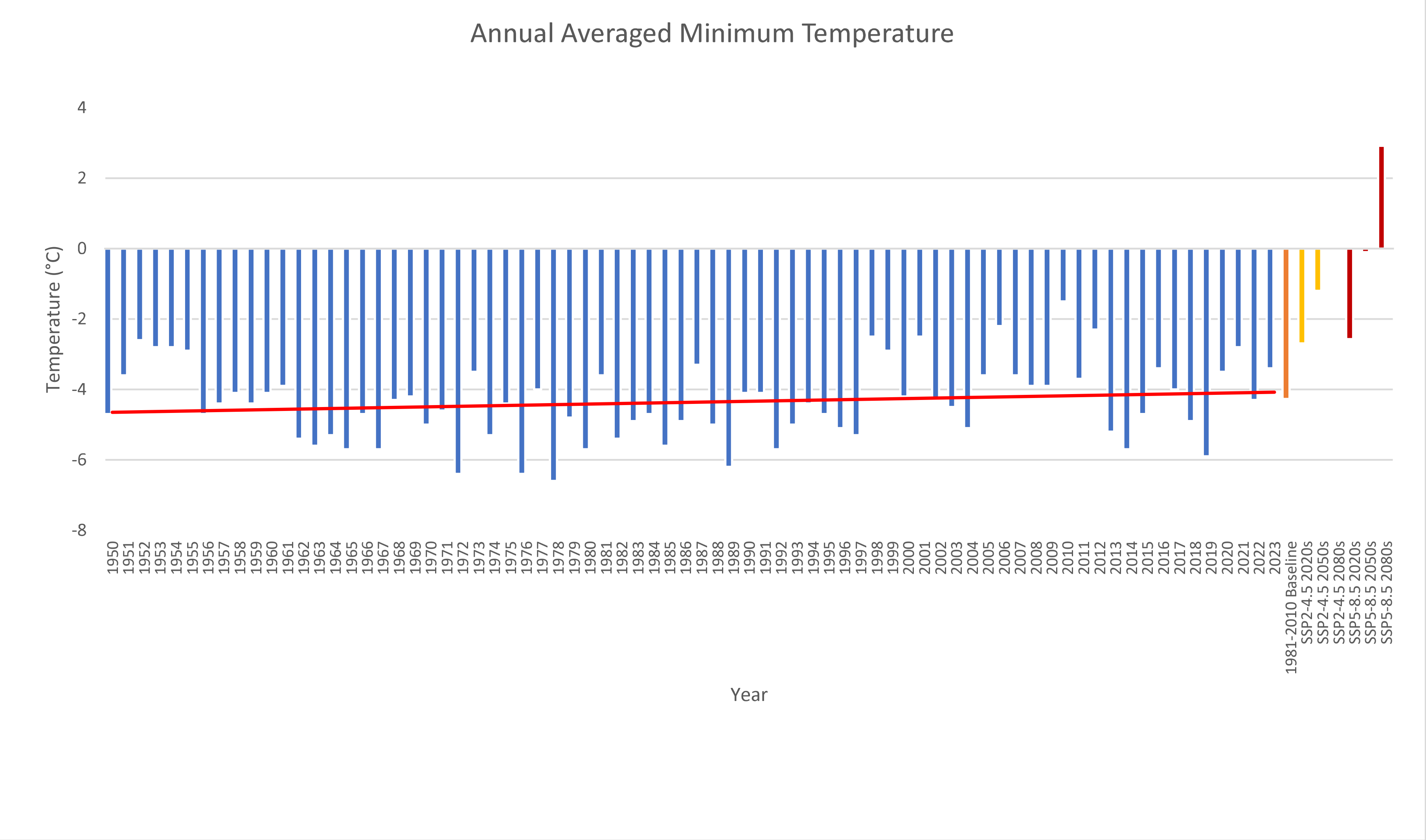


Figure 8 Annual and Project Minimum Temperature Averages



2.3.2 Extreme Minimum Temperature Frequency

It can also be useful to view projected increases in temperatures as the change in the occurrence of days with a temperature lower than a certain extreme cold threshold. The climate projections for the occurrence of days with temperatures lower than -15°C and -30°C are presented in Table 8. The frequency of extreme minimum temperatures is projected to decrease for the Timmins region.

Table 8 Summary of Historical and Projected Number of Days per Year with Minimum Daily Temperature ≤ -15°C and -30°C

Average Annual Number of Days with Min. Temp ≤ -15°C							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
85.1	83.0	71.4	69.9	59.2	49.9	49.6	28.3
Average Annual Number of Days with Min. Temp ≤ -30°C							
1981-2010 Baseline	**1991-2020 Baseline**	**2020s**		**2050s**		**2080s**	
		SSP2-4.5	**SSP5-8.5**	**SSP2-4.5**	**SSP5-8.5**	**SSP2-4.5**	**SSP5-8.5**
15.5	14.5	8.8	8.3	4.5	2.8	2.6	0.4

2.3.3 Frost Days

Frost days are days when the daily minimum temperature is less than 0°C, indicating when conditions are below freezing (typically overnight) and frost might form at ground level or on cold surfaces. Historical and projected estimates for average annual number of frost days for the Timmins area are shown in Table 9. The frequency of occurrence of frost days is projected to decrease under both SSP scenarios.

Table 9 Summary of Historical and Projected Annual Number of Frost Days

Average Annual Number of Frost Days							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
204.4	205.1	185.2	184.6	173.1	164.3	163.9	139.7

2.3.4 Ice Days

Ice days are days when the daily maximum temperature is less than 0°C, indicating when conditions are favorable for snow retention. Historical and projected estimates for average annual number of ice days in Timmins are shown in Table 10. The frequency of occurrence of ice days is projected to decrease under both SSP scenarios.

Table 10 Summary of Historical and Projected Annual Number of Ice Days

Average Annual Number of Ice Days							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
112.1	112.5	105.4	104.4	96.1	88.7	88.5	67.9

2.3.5 Heating Degree Days

Heating Degree Days (HDD) are equal to the number of degrees Celsius a given day's mean temperature is below 18°C. For example, if the daily mean temperature is 15°C, the HDD value for that day is equal to 3°C. HDD are totaled over a time period (e.g., monthly, seasonally, or annually).

HDD provide an indication of the heating capacity required to maintain comfortable building conditions during colder months. The historical and projected HDD values provided below demonstrate a decrease in cooling needs under future climate conditions in the Timmins region (Table 11).

Table 11 Average Annual Heating Degree Days

Average Annual Heating Degree Days (HDD)							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
5988.0	5921.6	5455.6	5424.8	5029.5	4726.6	4704.2	3949.4

3 Precipitation

3.1 Total Annual & Seasonal Accumulation

Total annual and seasonal precipitation and percent change in total precipitation from the baseline in Timmins region are shown in Table 12. Total annual and seasonal precipitation in the region for future climate periods is shown on Figure 9 to Figure 11. Annual, winter, spring and fall precipitation is projected to increase in Timmins with the largest percentage changes (+22.5% and +37.2%) occurring in winter while summer precipitation remains relatively unchanged (-0.4% and +0.1%) under SSP2-4.5 and SSP5-8.5, respectively by the 2080s.

Table 12 Average Percent Change in Total Precipitation from Baseline

Season	Average Annual Total Precipitation 1981-2010 (mm)	Average Annual Total Precipitation 1991-2020 (mm)	Average Annual Total Precipitation (mm) and Projected Percent Change in Total Precipitation from 1981-2010 Baseline (%)					
			2020s		2050s		2080s	
			SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Annual	826.5	798.8	867.9 (+5.0%)	866.2 (+4.8%)	899.1 (+8.8%)	917.4 (+11.0%)	915.7 (+10.8%)	978.1 (+18.3%)
Winter	153.2	141.4	166.5 (+8.7%)	168.2 (+9.8%)	175.6 (+14.6%)	187.1 (+22.1%)	187.7 (+22.5%)	210.2 (+37.2%)
Spring	174.1	173.0	188.0 (+8.0%)	188.2 (+8.1%)	197.4 (+13.4%)	204.9 (+17.7%)	205.5 (+18.0%)	225.8 (+29.7%)
Summer	256.0	243.8	262.3 (+2.5%)	260.2 (+1.6%)	262.0 (+2.3%)	258.1 (+0.8%)	255.0 (-0.4%)	256.2 (+0.1%)
Autumn	243.1	240.6	250.5 (+3.0%)	249.0 (+2.4%)	263.4 (+8.4%)	266.0 (+9.4%)	266.2 (+9.5%)	283.8 (+16.8%)

Figure 9 Average Annual Total Precipitation

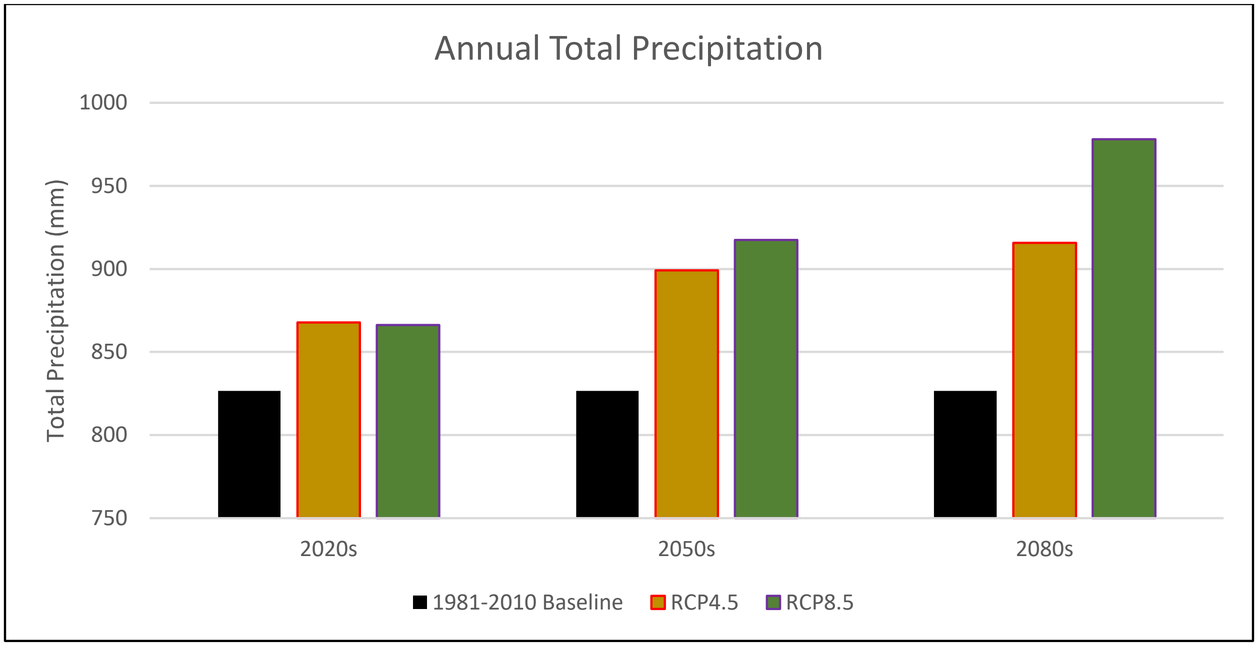


Figure 10 Average Seasonal Total Precipitation

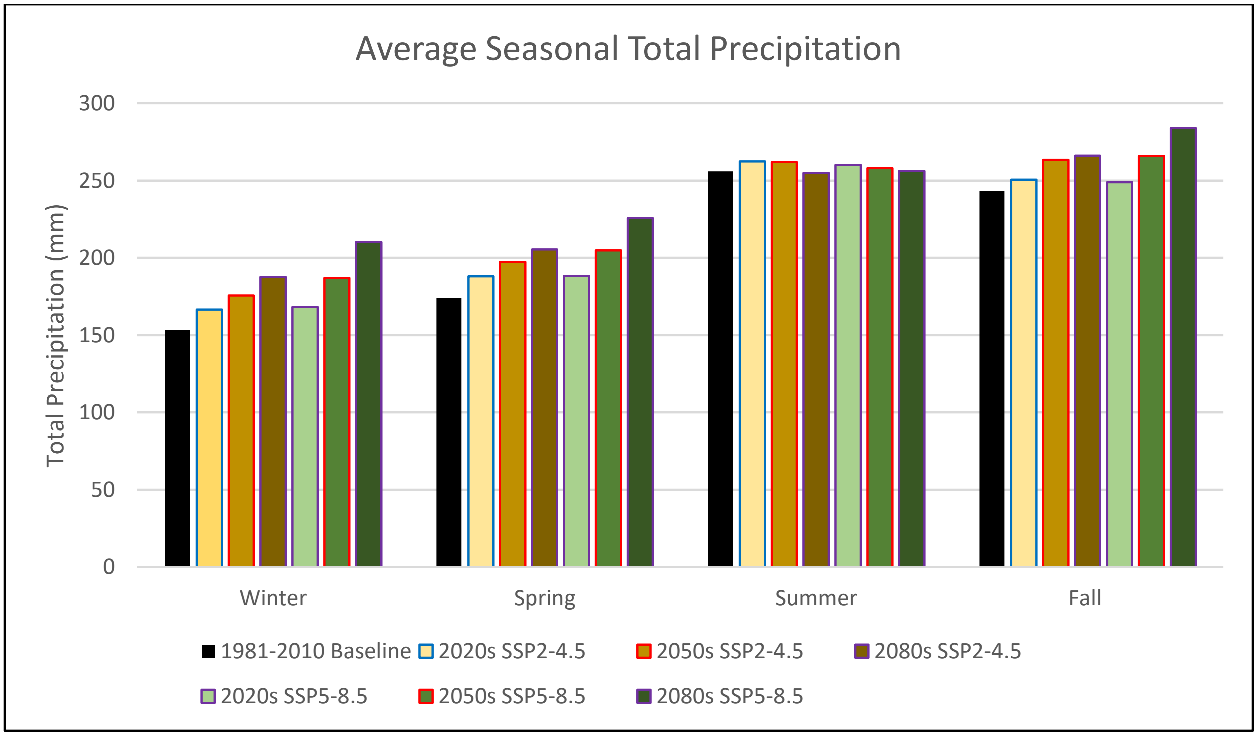
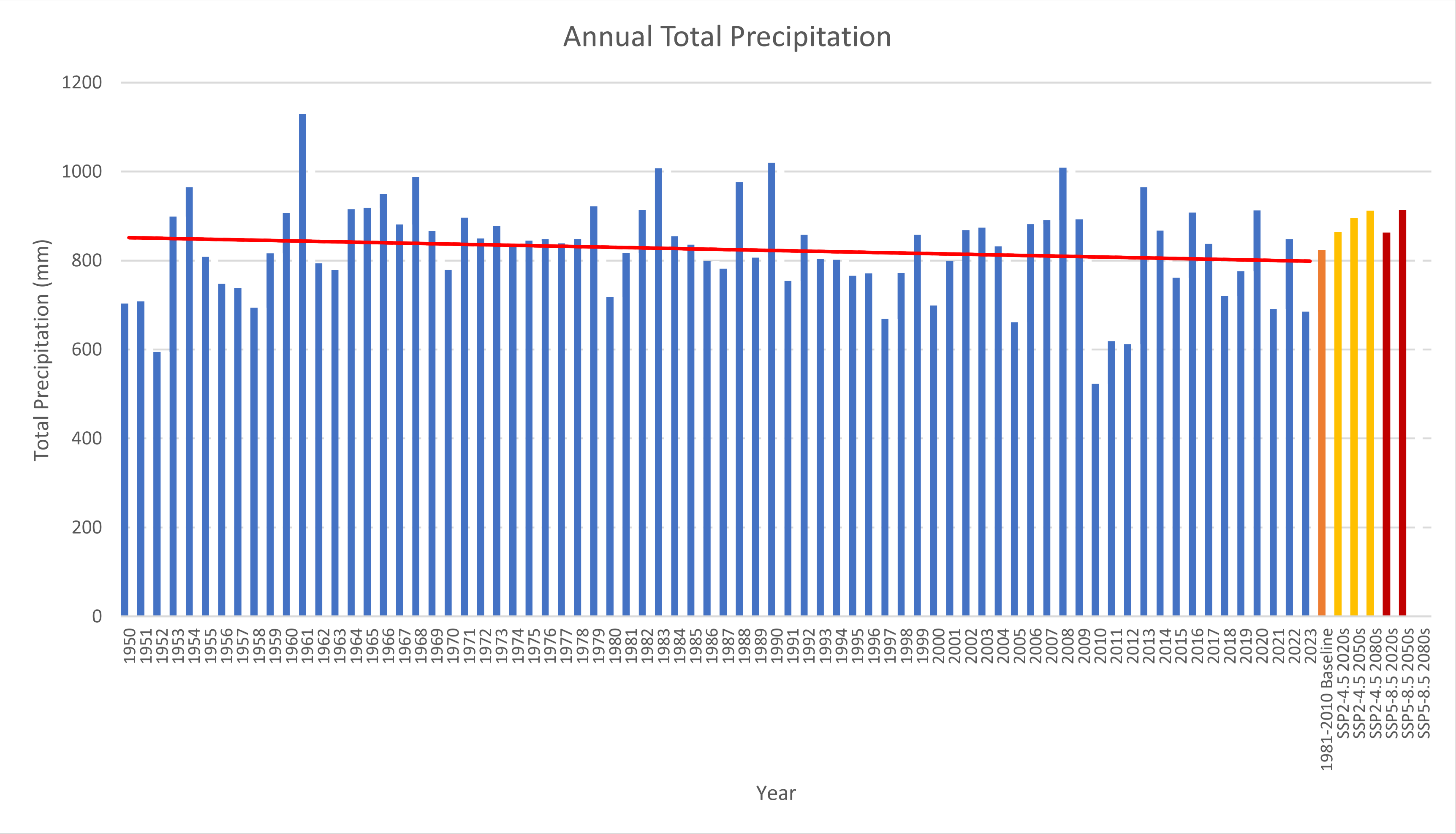


Figure 11 Average Annual Total Precipitation



3.2 1,3,5 Day Accumulation

Observations from Timmins ECCC weather stations were chosen for the complete datasets of precipitation for the years from 1950 to 2023 for the studied region. Record 1, 3, and 5-day precipitation accumulations at the airport are shown in Table 13. Historical and projected estimates for maximum 1, 3, and 5-day precipitation accumulation in the region are shown in Table 14. The precipitation accumulation for 1, 3 and 5-day events is projected to increase under all studied SSP scenarios in the region.

Table 13 Historical Maximum 1, 3, and 5-Day Precipitation Event Accumulation

	Record Maximum Precipitation Accumulation (mm)		
	1-day	**3-day**	**5-day**
Precipitation (mm)	105.2	153.2	156.3
Event Date	2016-08-20	2016-08-21	1953-09-13

Table 14 Historical and Projected Average Annual Maximum 1, 3, and 5-Day Precipitation Accumulations

	Average Annual Maximum Precipitation Accumulation (mm)							
	1981-2010 Baseline	**1991-2020 Baseline**	**2020s**		**2050s**		**2080s**	
Duration			**SSP2-4.5**	**SSP5-8.5**	**SSP2-4.5**	**SSP5-8.5**	**SSP2-4.5**	**SSP5-8.5**
1-Day	42.43	42.68	45.98	44.98	47.20	48.86	48.37	52.55
3-Day	58.92	59.26	64.56	63.46	66.95	68.55	68.38	72.77
5-day	66.64	67.3	72.57	71.02	75.05	76.85	77.03	82.31

3.3 Intensity-Duration-Frequency (IDF)

A common way of representing extreme rainfall is through the use of intensity-duration-frequency (IDF) data sets. The IDF curves are a statistical model of how often (i.e., the frequency) a certain amount of rain (i.e., the intensity, usually in mm) will occur over a certain amount of time (e.g., a duration of 10 minutes or 1 hour). The statistics are typically based on hourly and sub-hourly precipitation measurements.

Evaluating historical and projected IDF data provides insight into how the intensity, duration, and frequency of precipitation events will change under future climate conditions. IDF data relates short-duration, high rainfall intensity with its frequency of occurrence. When IDF data is not available from a representative weather station within the climate zone, “ungauged” historical IDF data, calculated through interpolation between ECCC weather stations in the region can be used. Timmins Climate (Station ID: 6078282) is the nearest station to the Project location and provides 61 years of IDF data, covering the 1952-2021 time period. Historical IDF data from the Timmins Climate weather station (Station ID:

6078282) has been selected to evaluate the future changes in intensity, duration, and frequency of precipitation events for the Timmins region. Historical IDF data for the Timmins region is provided in Table 15 to Table 18. The values in the tables represent the mean precipitation amount of the model ensemble, while the values within the parenthesis indicated the range from the 10th percentile to the 90th percentile of the model ensemble.

The Canadian Standards Association Group's (CSA) Rainfall Intensity-Duration-Frequency Guide (CSA PLUS 4013:19) and ECCC recommend using the Clausius-Clapeyron (C-C) relation method for estimating projected changes to short duration, high intensity precipitation events (CSA 2019). The C-C relation is founded on the atmospheric physics theoretical relationship between air temperature and the holding capacity of the atmosphere (i.e., the amount of water the air could potentially contain). The C-C relation indicates on average, a 7% increase in the air's holding capacity per 1°C of local warming. A similar or greater rate of increase in precipitation amounts is likely under a warming climate, dependent on the event duration. Rainfall versus temperature relationships close to the C-C relation have been detected globally and regionally in observational studies (Panthou, Vischel and Lebel 2014) (Prein, et al. 2016) (Westra, Alexander and Zwiers 2013) (Barbero, et al. 2017). Therefore, the IDF projections presented in this assessment are calculated following the C-C relation method.

$$R_P = R_C \times 1.07^{\Delta T}$$

Where R_P is the future estimated rainfall intensity value, R_C is the current rainfall intensity value, and ΔT is the long-term (30-year mean) annual mean temperature change for the study location between the target time horizon (e.g., 2050s) and baseline period.

Table 15 Historical Precipitation Event Accumulation IDF Data (mm)

Return Periods (years)	2	5	10	20	25	50	100
5-min	6.97	9.07	10.33	11.44	11.77	12.75	13.64
10-min	9.98	13.39	15.6	17.68	18.33	20.31	22.24
15-min	11.85	15.94	18.64	21.23	22.05	24.57	27.07
30-min	14.72	20.49	24.8	29.33	30.86	35.86	41.28
1-hr	17.55	24.29	29.55	35.3	37.28	43.92	51.37
2-hr	21.33	28.49	33.91	39.68	41.63	48.07	55.14
6-hr	28.05	37.59	45.92	55.84	59.46	72.26	87.89
12-hr	34.12	47.49	58.73	71.74	76.4	92.58	111.79
24-hr	42.56	60.38	74.92	91.39	97.19	117.06	140.15

Table 16 Projected Precipitation Event Accumulation IDF Data (mm) for the 2020s (2011-2040)

SSP2-4.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	7.7 (7.6-8.3)	10.1 (9.8-10.8)	11.5 (11.2-12.3)	12.7 (12.4-13.7)	13.1 (12.8-14.1)	14.2 (13.8-15.2)	15.1 (14.8-16.3)
10-min	11.1 (10.8-11.9)	14.9 (14.5-16.0)	17.3 (16.9-18.6)	19.6 (19.2-21.1)	20.3 (19.9-21.9)	22.5 (22.0-24.3)	24.7 (24.1-26.6)
15-min	13.2 (12.8-14.2)	17.7 (17.3-19.1)	20.7 (20.2-22.3)	23.6 (23.0-25.4)	24.5 (23.9-26.4)	27.3 (26.6-29.4)	30.0 (29.3-32.4)
30-min	16.3 (16.0-17.6)	22.7 (22.2-24.5)	27.5 (26.9-29.6)	32.6 (31.8-35.1)	34.3 (33.4-36.9)	39.8 (38.9-42.9)	45.8 (44.7-49.3)
1-hr	19.5 (19.0-21.0)	27.0 (26.3-29.0)	32.8 (32.0-35.3)	39.2 (38.3-42.2)	41.4 (40.4-44.6)	48.8 (47.6-52.5)	57.0 (55.7-61.4)
2-hr	23.7 (23.1-25.5)	31.6 (30.9-34.1)	37.6 (36.7-40.5)	44.0 (43.0-47.4)	46.2 (45.1-49.8)	53.4 (52.1-57.5)	61.2 (59.8-65.9)
6-hr	31.1 (30.4-33.5)	41.7 (40.7-44.9)	51.0 (49.8-54.9)	62.0 (60.5-66.8)	66.0 (64.4-71.1)	80.2 (78.3-86.4)	97.6 (95.2-105.1)
12-hr	37.9 (37.0-40.8)	52.7 (51.5-56.8)	65.2 (63.6-70.2)	79.6 (77.7-85.8)	84.8 (82.8-91.3)	102.8 (100.3-110.7)	124.1 (121.1-133.6)
24-hr	47.2 (46.1-50.9)	67.0 (65.4-72.2)	83.2 (81.2-89.6)	101.4 (99.0-109.2)	107.9 (105.3-116.2)	129.9 (126.9-139.9)	155.6 (151.9-167.5)
SSP5-8.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	7.8 (7.5-8.4)	10.1 (9.8-10.9)	11.5 (11.2-12.4)	12.8 (12.4-13.8)	13.2 (12.7-14.2)	14.3 (13.8-15.4)	15.2 (14.7-16.4)
10-min	11.2 (10.8-12.0)	15.0 (14.5-16.1)	17.4 (16.9-18.8)	19.8 (19.1-21.3)	20.5 (19.8-22.1)	22.7 (22.0-24.5)	24.9 (24.0-26.8)
15-min	13.2 (12.8-14.3)	17.8 (17.2-19.2)	20.8 (20.1-22.5)	23.7 (22.9-25.6)	24.7 (23.8-26.6)	27.5 (26.6-29.6)	30.3 (29.3-32.6)
30-min	16.5 (15.9-17.7)	22.9 (22.1-24.7)	27.7 (26.8-29.9)	32.8 (31.7-35.3)	34.5 (33.4-37.2)	40.1 (38.8-43.2)	46.2 (44.6-49.7)

SSP2-4.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
1-hr	19.6 (19.0-21.2)	27.2 (26.3-29.3)	33.0 (31.9-35.6)	39.5 (38.2-42.5)	41.7 (40.3-44.9)	49.1 (47.5-52.9)	57.4 (55.5-61.9)
2-hr	23.8 (23.1-25.7)	31.9 (30.8-34.3)	37.9 (36.6-40.9)	44.4 (42.9-47.8)	46.5 (45.0-50.2)	53.7 (52.0-57.9)	61.6 (59.6-66.5)
6-hr	31.4 (30.3-33.8)	42.0 (40.6-45.3)	51.3 (49.6-55.3)	62.4 (60.4-67.3)	66.5 (64.3-71.7)	80.8 (78.1-87.1)	98.3 (95.0-105.9)
12-hr	38.1 (36.9-41.1)	53.1 (51.3-57.2)	65.7 (63.5-70.8)	80.2 (77.5-86.5)	85.4 (82.6-92.1)	103.5 (100.1-111.6)	125.0 (120.8-134.7)
24-hr	47.6 (46.0-51.3)	67.5 (65.3-72.8)	83.8 (81.0-90.3)	102.2 (98.8-110.1)	108.7 (105.0-117.1)	130.9 (126.5-141.1)	156.7 (151.5-168.9)

Table 17 Projected Precipitation Event Accumulation IDF Data (mm) for the 2050s (2041-2070)

SSP2-4.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	8.5 (8.1-9.4)	11.1 (10.5-12.2)	12.6 (11.9-13.9)	14.0 (13.2-15.4)	14.4 (13.6-15.9)	15.6 (14.7-17.2)	16.6 (15.8-18.4)
10-min	12.2 (11.5-13.5)	16.3 (15.5-18.1)	19.0 (18.0-21.0)	21.6 (20.4-23.8)	22.4 (21.2-24.7)	24.8 (23.5-27.4)	27.1 (25.7-30.0)
15-min	14.5 (13.7-16.0)	19.5 (18.4-21.5)	22.8 (21.6-25.1)	25.9 (24.6-28.6)	26.9 (25.5-29.7)	30.0 (28.4-33.1)	33.0 (31.3-36.5)
30-min	18.0 (17.0-19.8)	25.0 (23.7-27.6)	30.3 (28.7-33.4)	35.8 (33.9-39.5)	37.7 (35.7-41.6)	43.8 (41.5-48.4)	50.4 (47.7-55.7)
1-hr	21.4 (20.3-23.7)	29.6 (28.1-32.8)	36.1 (34.2-39.8)	43.1 (40.8-47.6)	45.5 (43.1-50.3)	53.6 (50.8-59.2)	62.7 (59.4-69.3)
2-hr	26.0 (24.7-28.8)	34.8 (32.9-38.4)	41.4 (39.2-45.7)	48.4 (45.9-53.5)	50.8 (48.1-56.1)	58.7 (55.6-64.8)	67.3 (63.8-74.3)
6-hr	34.2 (32.4-37.8)	45.9 (43.5-50.7)	56.0 (53.1-61.9)	68.2 (64.6-75.3)	72.6 (68.8-80.2)	88.2 (83.6-97.4)	107.3 (101.6-118.5)
12-hr	41.6 (39.5-46.0)	58.0 (54.9-64.0)	71.7 (67.9-79.2)	87.6 (83.0-96.7)	93.2 (88.3-103.0)	113.0 (107.1-124.8)	136.4 (129.3-150.7)
24-hr	51.9 (49.2-57.4)	73.7 (69.8-81.4)	91.4 (86.6-101.0)	111.5 (105.7-123.2)	118.6 (112.4-131.0)	142.9 (135.4-157.8)	171.1 (162.1-189.0)

SSP5-8.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	9.1 (8.6-10.2)	11.9 (11.2-13.3)	13.5 (12.8-15.2)	15.0 (14.1-16.8)	15.4 (14.6-17.3)	16.7 (15.8-18.7)	17.9 (16.9-20.0)
10-min	13.1 (12.3-14.7)	17.5 (16.6-19.7)	20.4 (19.3-22.9)	23.1 (21.9-26.0)	24.0 (22.7-26.9)	26.6 (25.1-29.8)	29.1 (27.5-32.7)
15-min	15.5 (14.7-17.4)	20.9 (19.7-23.4)	24.4 (23.0-27.4)	27.8 (26.3-31.2)	28.9 (27.3-32.4)	32.2 (30.4-36.1)	35.4 (33.5-39.8)
30-min	19.3 (18.2-21.6)	26.8 (25.3-30.1)	32.5 (30.7-36.4)	38.4 (36.3-43.1)	40.4 (38.2-45.3)	46.9 (44.3-52.7)	54.0 (51.0-60.6)
1-hr	23.0 (21.7-25.8)	31.8 (30.0-35.7)	38.7 (36.5-43.4)	46.2 (43.7-51.8)	48.8 (46.1-54.7)	57.5 (54.3-64.5)	67.2 (63.5-75.4)
2-hr	27.9 (26.4-31.3)	37.3 (35.2-41.8)	44.4 (41.9-49.8)	51.9 (49.1-58.3)	54.5 (51.5-61.1)	62.9 (59.4-70.6)	72.2 (68.2-81.0)
6-hr	36.7 (34.7-41.2)	49.2 (46.5-55.2)	60.1 (56.8-67.4)	73.1 (69.0-82.0)	77.8 (73.5-87.3)	94.6 (89.4-106.1)	115.0 (108.7-129.1)
12-hr	44.7 (42.2-50.1)	62.2 (58.7-69.7)	76.9 (72.6-86.2)	93.9 (88.7-105.3)	100.0 (94.5-112.2)	121.2 (114.5-135.9)	146.3 (138.2-164.2)
24-hr	55.7 (52.6-62.5)	79.0 (74.7-88.7)	98.1 (92.6-110.0)	119.6 (113.0-134.2)	127.2 (120.2-142.7)	153.2 (144.8-171.9)	183.5 (173.3-205.8)

Table 18: Projected Precipitation Event Accumulation IDF Data (mm) for the 2080s (2071-2100)

SSP2-4.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	9.2 (8.6-10.3)	11.9 (11.2-13.4)	13.6 (12.7-15.3)	15.0 (14.1-16.9)	15.5 (14.5-17.4)	16.8 (15.7-18.9)	17.9 (16.8-20.2)
10-min	13.1 (12.3-14.8)	17.6 (16.5-19.8)	20.5 (19.2-23.1)	23.3 (21.7-26.2)	24.1 (22.5-27.1)	26.7 (25.0-30.0)	29.3 (27.4-32.9)
15-min	15.6 (14.6-17.5)	21.0 (19.6-23.6)	24.5 (22.9-27.6)	27.9 (26.1-31.4)	29.0 (27.1-32.6)	32.3 (30.2-36.3)	35.6 (33.3-40.0)
30-min	19.4 (18.1-21.8)	27.0 (25.2-30.3)	32.6 (30.5-36.7)	38.6 (36.1-43.4)	40.6 (38.0-45.7)	47.2 (44.1-53.0)	54.3 (50.8-61.1)
1-hr	23.1 (21.6-26.0)	32.0 (29.9-35.9)	38.9 (36.3-43.7)	46.4 (43.4-52.2)	49.0 (45.8-55.1)	57.8 (54.0-65.0)	67.6 (63.2-76.0)

SSP2-4.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
2-hr	28.1 (26.2-31.6)	37.5 (35.0-42.1)	44.6 (41.7-50.2)	52.2 (48.8-58.7)	54.8 (51.2-61.6)	63.2 (59.1-71.1)	72.5 (67.8-81.6)
6-hr	36.9 (34.5-41.5)	49.4 (46.2-55.6)	60.4 (56.5-67.9)	73.5 (68.7-82.6)	78.2 (73.1-88.0)	95.1 (88.9-106.9)	115.6 (108.1-130.0)
12-hr	44.9 (42.0-50.5)	62.5 (58.4-70.3)	77.3 (72.2-86.9)	94.4 (88.2-106.1)	100.5 (94.0-113.0)	121.8 (113.9-137.0)	147.1 (137.5-165.4)
24-hr	56.0 (52.3-63.0)	79.4 (74.3-89.3)	98.6 (92.1-110.8)	120.2 (112.4-135.2)	127.9 (119.5-143.8)	154.0 (144.0-173.2)	184.4 (172.4-207.3)

SSP5-8.5							
Return Periods (years)	**2**	**5**	**10**	**20**	**25**	**50**	**100**
5-min	11.1 (10.0-13.2)	14.4 (13.0-17.2)	16.4 (14.8-19.6)	18.2 (16.4-21.7)	18.7 (16.9-22.4)	20.3 (18.3-24.2)	21.7 (19.6-25.9)
10-min	15.9 (14.3-19.0)	21.3 (19.2-25.4)	24.8 (22.4-29.6)	28.1 (25.4-33.6)	29.1 (26.3-34.8)	32.3 (29.1-38.6)	35.3 (31.9-42.3)
15-min	18.8 (17.0-22.5)	25.3 (22.9-30.3)	29.6 (26.7-35.4)	33.7 (30.4-40.3)	35.0 (31.6-41.9)	39.0 (35.2-46.7)	43.0 (38.8-51.4)
30-min	23.4 (21.1-28.0)	32.6 (29.4-38.9)	39.4 (35.6-47.1)	46.6 (42.1-55.7)	49.0 (44.3-58.6)	57.0 (51.4-68.1)	65.6 (59.2-78.4)
1-hr	27.9 (25.2-33.3)	38.6 (34.8-46.2)	47.0 (42.4-56.2)	56.1 (50.6-67.1)	59.2 (53.5-70.8)	69.8 (63.0-83.5)	81.6 (73.7-97.6)
2-hr	33.9 (30.6-40.5)	45.3 (40.9-54.1)	53.9 (48.6-64.4)	63.1 (56.9-75.4)	66.2 (59.7-79.1)	76.4 (68.9-91.3)	87.6 (79.1-104.8)
6-hr	44.6 (40.2-53.3)	59.7 (53.9-71.4)	73.0 (65.9-87.3)	88.7 (80.1-106.1)	94.5 (85.3-113.0)	114.8 (103.6-137.3)	139.7 (126.0-167.0)
12-hr	54.2 (48.9-64.8)	75.5 (68.1-90.2)	93.3 (84.2-111.6)	114.0 (102.9-136.3)	121.4 (109.6-145.2)	147.1 (132.8-175.9)	177.7 (160.3-212.4)
24-hr	67.6 (61.0-80.9)	96.0 (86.6-114.7)	119.1 (107.4-142.4)	145.2 (131.1-173.7)	154.5 (139.4-184.7)	186.0 (167.9-222.4)	222.7 (201.0-266.3)

The results indicate that an increase in precipitation accumulation can be expected at the Timmins Climate weather station for most of the precipitation events. For the 2020s, the projected percentage change from historical periods for precipitation events is estimated to be 11.0% and 11.8% under SSP2-4.5 and SSP5-8.5, respectively. For the 2050s, the projected percentage change from historical periods for precipitation events is estimated to be 22.1% and 30.9% under SSP2-4.5 and SSP5-8.5, respectively. For the 2080s, the projected percentage change from historical periods for precipitation events is estimated to be 31.6% and 58.9% under SSP2-4.5 and SSP5-8.5, respectively.

Under both SSP2-4.5 and SSP5-8.5 scenarios, the total precipitation accumulation for all durations is expected to increase throughout the studied periods. High intensity rainfall events will occur more frequently and are expected to be more severe for future periods under climate change. For example, a 100-year 1-hour precipitation event with 51.4 mm of precipitation will have a return period of 20 years by the 2080s, while a 100-year 1-hour event by 2080s is expected to have an accumulation of 81.6 mm under SSP5-8.5.

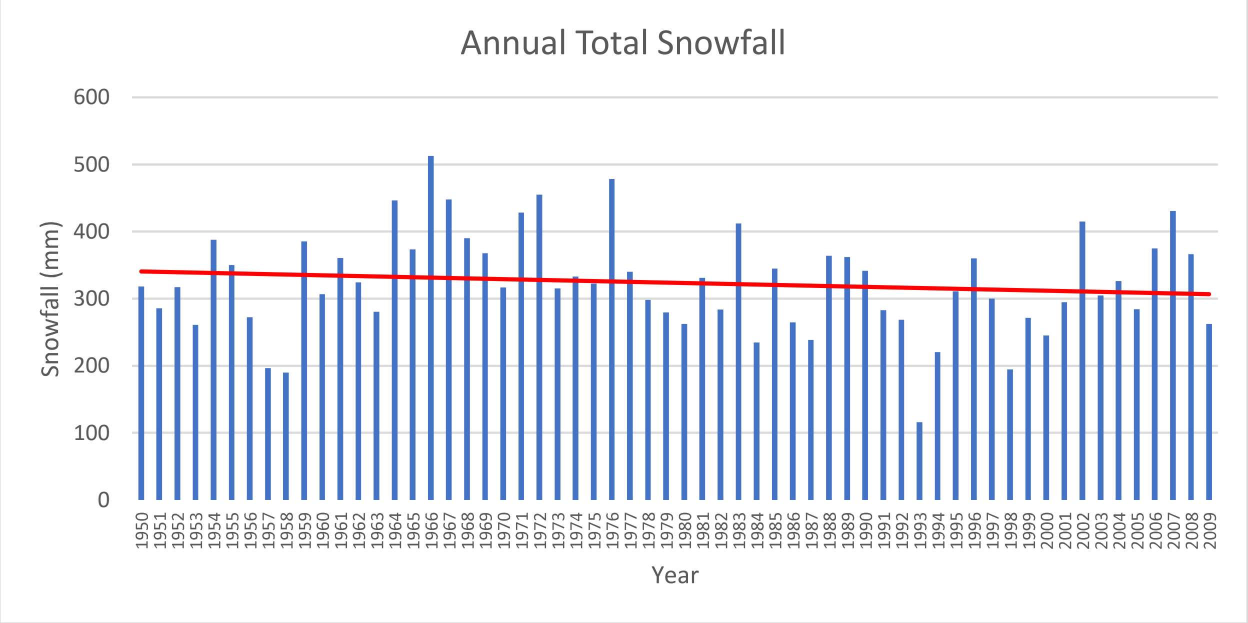
3.4 Snow

The historical occurrence of snowfall in the Timmins region is based on the observations of ECCC weather stations for 1950 to 2009 are shown in Table 19 and Figure 12. Overall, snowfall is projected to decrease and convert into winter rainfall under a warming climate in the Timmins region (Ahmed, et al. 2022). However, large snow events will remain possible under climate change due to cold air outbreaks and storm tracks. Under SSP2-4.5 and SSP5-8.5, the occurrence of heavy snowfall events is projected to remain similar to historical periods (Janoski, et al. 2018).

Table 19 Days with snowfall from 1950-2009 (Timmins and Timmins Victor Power A, Station IDs: 6078280 and 6078285)

Snowfall	Days/year
≥ 0.2 cm	72.8
≥ 5.0 cm	15.5
≥ 10.0 cm	5.4
≥ 25.0 cm	0.3

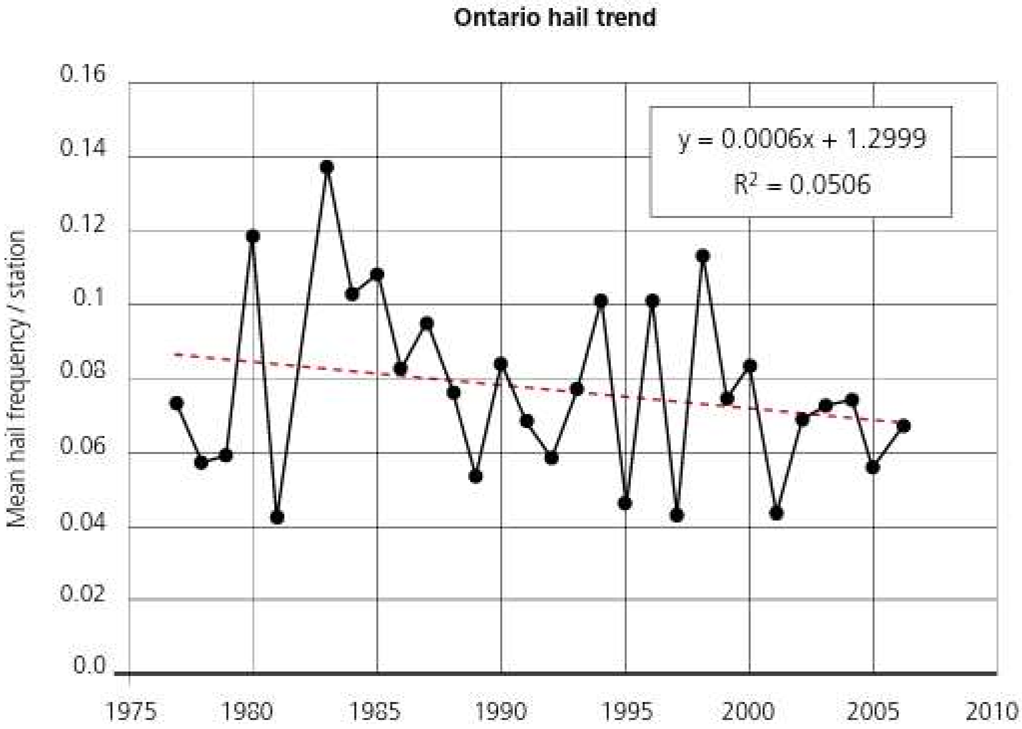
Figure 12 Total Historic Annual Snowfall



3.5 Hail

Hail is described as precipitation consisting of ice particles in various shapes with a minimum diameter of 5 mm generally observed during thunderstorms (AMS 2017). Historical data for Ontario was obtained from ECCC hail observing stations for the period of 1977 to 2007 is shown on Figure 13 (Etkin 2018). A notable hailstorm event accompanied with thunderstorms occurred in 2017 over the Timmins region, when hail as large as 5 cm fell for approximately five minutes during a thunderstorm.

Figure 13 Historic Trends in Hail Frequency for Ontario (Etkin 2018)



Due to the complex, localized, and short duration nature of hailstorms, current climate projections are not able to indicate future changes in occurrence in a quantitative way. Additionally, as hailstorm damages follow a fat-tailed distribution, the very rare extreme events account for a relatively large fraction of total consequences (Clauset, Shalizi and Newman 2009). Thus, it is difficult to use annualized losses as a predictor to future risk. However, hail may become a greater issue in the future due to the potentially increasing frequency of thunderstorms (Brooks, Carbin and Marsh. 2014).

3.6 Freezing Rain

Freezing rain is described as supercooled rain that freezes on impact to form a coating of clear ice on the exposed surfaces. Under climate change projections, warming temperature in a future climate may increase the likelihood of freezing rain event by 2050s and 2080s (Cheng, Li and Auld 2011). Freezing rain events in winter months (December, January, and February) could increase by about 40 to 100% in Timmins for 2080s. For the months of November, March and April, freezing rain events are projected to increase by 10 to 40% for the future periods. However, other studies, using different freezing rain simulation methods and GCM ensembles have suggested total annual freezing rain hours may decrease under warming temperatures, while extreme events remain possible (McCray, et al. 2022). Therefore, it is difficult to determine how freezing rain events will impact the Timmins area due to limited supporting data and significant uncertainty.

4 Freeze-Thaw Cycles

Freeze-thaw cycles are defined as days when the maximum temperature is greater than 0°C and the minimum temperature equal to or less than -1°C. A minimum temperature threshold of -1°C (instead of 0°C) is used to increase the likelihood that water present at the surface freezes. The historical and projected annual number of freeze-thaw cycles in Timmins are presented in Table 20. The annual number of freeze-thaw cycles is projected to slightly decrease under SSP2-4.5 and SSP5-8.5 in Timmins.

It is important to note that the historical periods of all CanDCS-U6 ensemble freeze-thaw cycle values are slight lower than the ECCC observations data. Thus, projected freeze-thaw cycle values for each SSP scenario were calculated from the percentage change between CanDCS-U6 future projections and historical simulations. The historical annual freeze-thaw cycle baseline values in the models are 78.87 and 79.5 for 1981-2010 and 1991-2020, respectively. Due to the complexity of freeze-thaw cycles and the inherent biases in the ensemble, freeze thaw cycles are generally underestimated in historical climate simulations.

As the SSP2-4.5 and SSP5-8.5 scenarios are composed of various sizes of climate models with different GCM drivers, some ensembles may present a 'warmer' climate than other, which is reflected in the differences between the annual freeze-thaw cycles of each SSP scenario. However, their sensitivity to climate change remains relevant for the climate change risk assessment as the models still capture the trends of the parameter. Thus, by applying the percentage change to the recorded historical ECCC data, it is still possible to show the projected annual freeze-thaw cycle values. Figure 14 and Figure 15 show the monthly freeze-thaw cycles for each studied period under SSP2-4.5 and SSP5-8.5 climate change scenarios. It is important to note that while the projected annual freeze-thaw cycles are decreasing, freeze-thaw cycles from December to March show a slight increase.

Table 20 Historical and Projected Annual Freeze-Thaw Cycles

Average Annual Free-Thaw Cycles							
1981-2010 Baseline	1991-2020 Baseline	2020s		2050s		2080s	
		SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
78.9	79.5	74.6	75.5	68.8	67.4	62.1	59.9

Figure 14 Monthly Freeze Thaw Cycle for the Studied Time Periods in the Timmins Regions Under SSP2-4.5

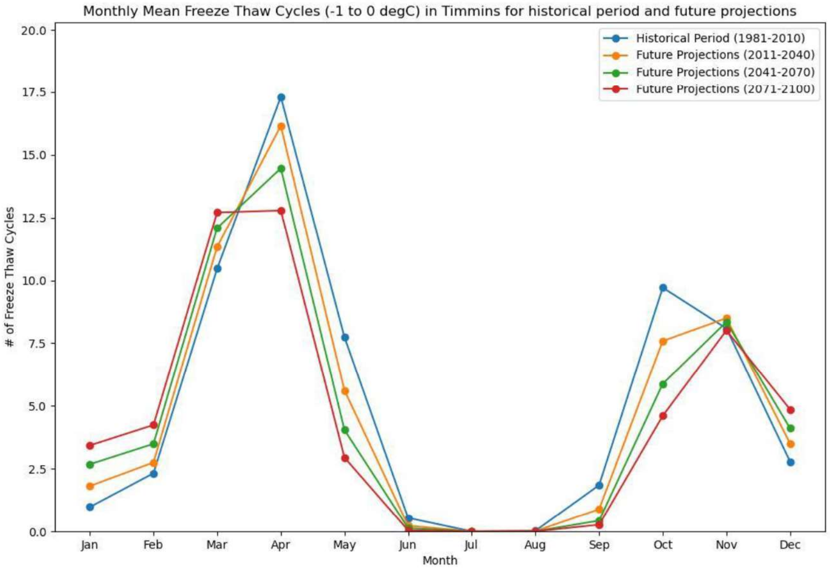
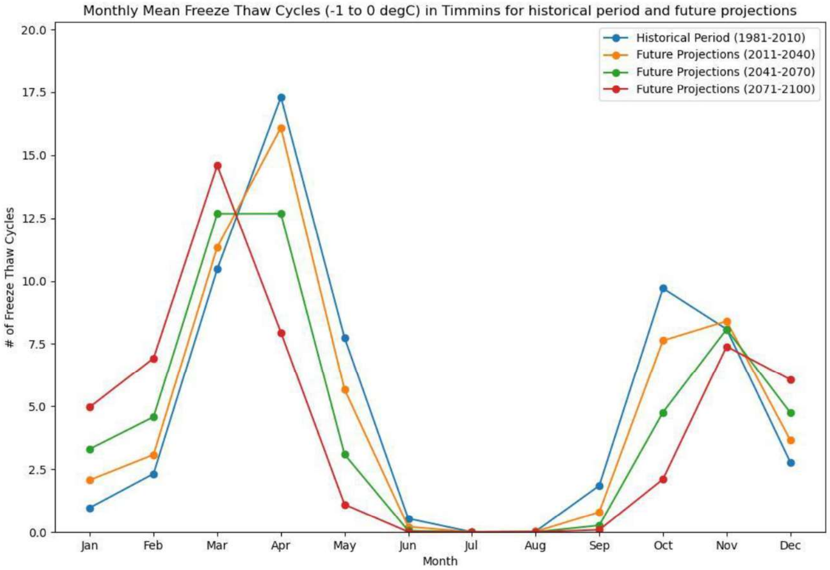


Figure 15 Monthly Freeze Thaw Cycle for the Studied Time Periods in the Timmins Region Under SSP5-8.5



5 Wind

The Timmins A (Station ID: 6078286), Timmins Victor Power A (Station ID: 6078285) and Timmins Climate (Station ID: 6078282) weather stations were merged to obtain the complete hourly and daily wind data for the period of 1955-2024. The recorded hourly wind data show 16.6% calm data. Recorded daily wind gusts data show approximately 47.7% data with wind gusts of <31 kilometres per hour (kph).

The available wind data is used to generate a windrose for the Timmins region. Windroses show the distribution of wind direction (direction from which the wind is blowing) observed at a particular location over a time period. The length of each line represents the frequency of the wind from that direction. Therefore, windroses provide information on the prevailing wind direction(s) and wind speeds at a given location. Figure 16 displays hourly and daily mean wind speed and direction, and Figure 17 shows the maximum wind gusts speed and direction observed from 1955 to 2024 in the Timmins region.

Figure 16 Hourly Mean Wind Speed and Direction from 1955 to 2024 Observed in Timmins Region

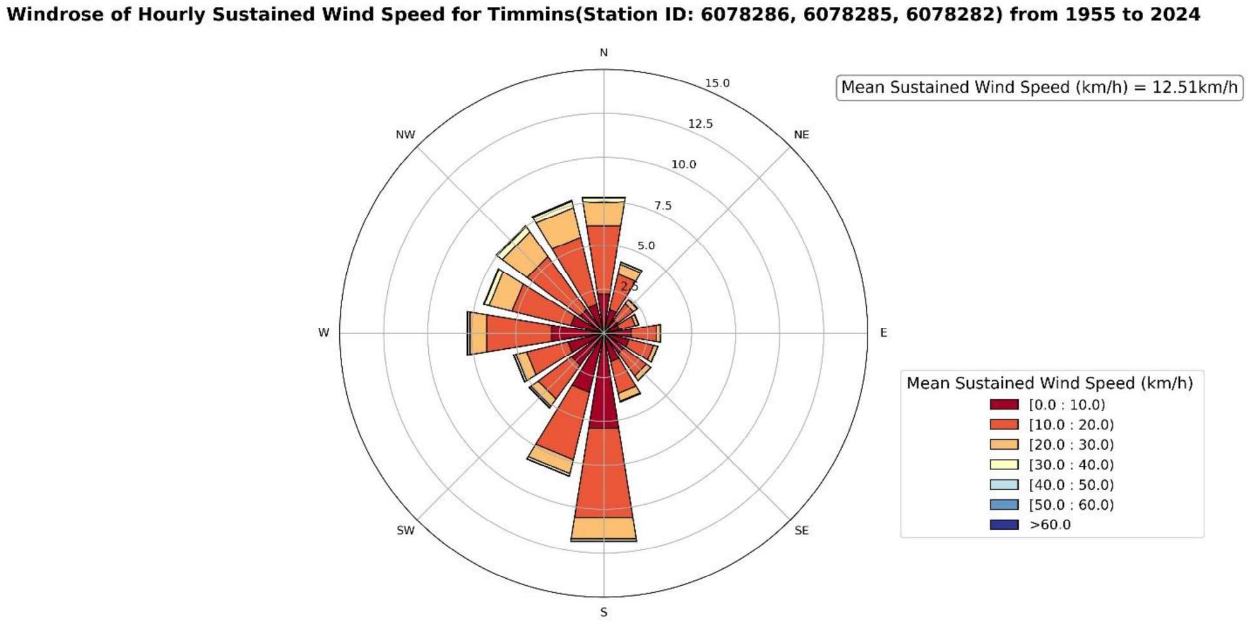
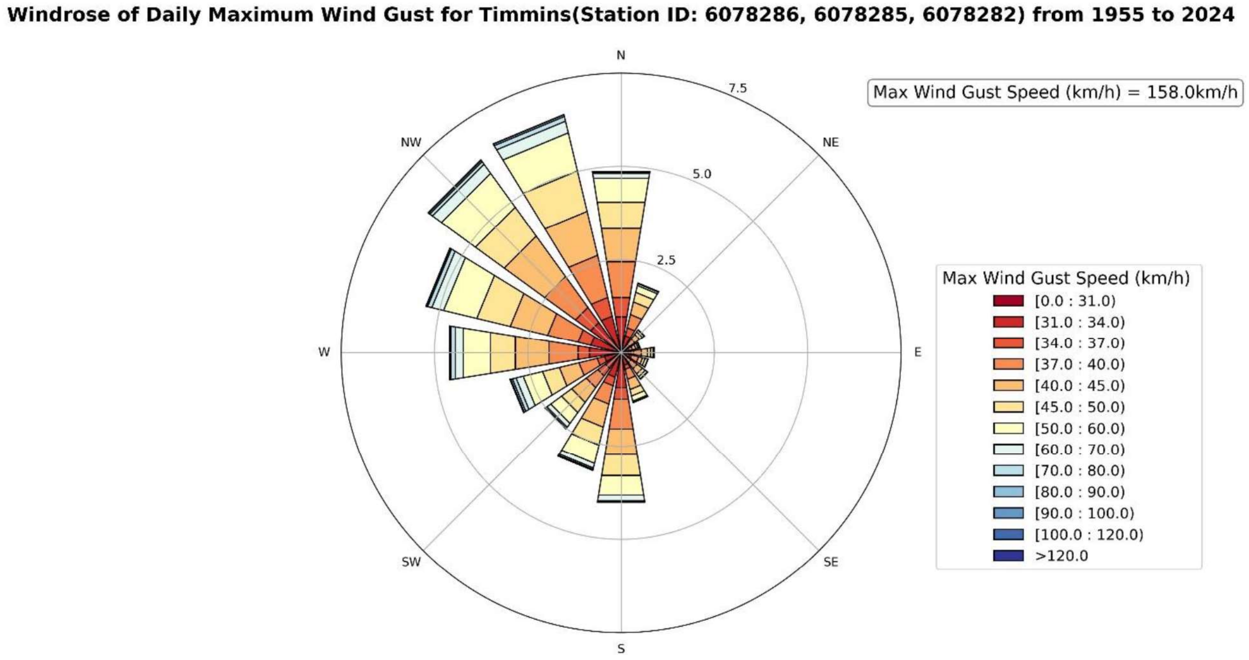


Figure 17 Daily Maximum Wind Gust Speed and Direction from 1955 to 2024 Observed in the Timmins Region



5.1 High Winds

High winds are defined as straight-line winds (to differentiate from tornadoes) including thunderstorm-associated winds (downbursts, microbursts) and winds from large-scale low-pressure systems, of sufficient strength to cause damage to exposed vegetation, buildings, and infrastructure.

For this climate profile, the wind gust hazard threshold analyzed is ≥70 kph. The higher threshold of 90 kph and 110 kph were selected as well for severe impacts. The higher threshold of 90 kph generally indicates the boundary between the "threshold of visible damage" and more severe impacts to infrastructure, buildings, and trees which can pose a threat to life (ECCC 2017).

A summary of the frequency of high winds is shown in Table 21. Baseline values were established from all available data measured at Timmins ECCC stations for gusts exceeding 70 kph, 90 kph and 110 kph. Table 21 shows days with high winds based on the historical data. There are 3.41 days/year for gusts ≥ 70 kph, 0.29 days/year for gusts ≥ 90 kph and 0.01 days/year for gusts ≥ 110 kph.

Table 21 Average Number of Days per Year with High Winds and Projected Trends (1955-2024)

High Winds	Baseline (2001-2023)	2020s	2050s	2080s
≥ 70kph	3.41 days/year	Increasing trend	Increasing trend	Increasing trend
≥ 90kph	0.29 days/year	Increasing trend	Increasing trend	Increasing trend
≥ 110kph	0.01 days/year	Increasing trend	Increasing trend	Increasing trend

Projected wind gust trends are based on peer reviewed published results of statistically downscaled future wind gusts above the 90 kph threshold (Cheng, et al. 2014). Using the ensemble of eight GCM simulations, the modeled results indicated that the frequencies of the wind gust events could increase over Canada under a warming a climate. The study also showed a consistent pattern of greater increases in gust frequency for successively higher thresholds. Hence, gusts above the 110 kph threshold are expected to increase at least by the same magnitude if not more than for the 90 kph threshold under climate change.

5.2 Tornadoes

A weak tornado with a strength of 0 in the enhanced Fujita scale (EF-scale) touched down at Victor M. Power airport on July 20, 2017, and moved through the Timmins area, resulting in some damage in a forested area. Another tornado with a strength of EF2 occurred northeast of Timmins on July 18, 2022. The 2.42 km-long storm track created a damage path near Gowanmarsh Lake and the estimated maximum wind speed was determined to be 190 kph.

To assess tornado occurrence near the Project site, a historical baseline was established using the Canadian Tornado Database (1980-2009), Northern Tornado Project (2019-2023) and media sources. It also important to note that the Canadian Tornado Database uses the Fujita scale (F-scale), and Northern Tornado Project uses the EF-scale to categorize their tornadoes. The F-scale only considers the maximum wind speed of the tornado, while the EF-scale also considers the damage caused by the tornado. During the period of 1980-2009, a total of three tornadoes were observed within 100 km radius of the Project site and all occurrences were F1 or lower. Table 22 shows the number and strength of tornadoes within 100 km of the Project site during the 1980-2009 period.

From 2019-2023, the Northern Tornado Project[4] recorded a total of five tornadoes within 100 km of the Project site (Table 23). The notable increase in tornado occurrences may be attributed to the advance in satellite imaging and communication technology.

Table 22 Historical Tornado Occurrences within 100 km of the Project Site (1980-2009)

Intensity	F0	F1	F2	F3	F4	F5
Occurrence	2	1	0	0	0	0

Table 23 Historical Tornado Occurrences within 100 km of the Project Site (2019-2023)

Intensity	EF0	EF1	EF2	EF3	EF4	EF5
Occurrence	1	2	2	0	0	0

Historical data on tornado occurrence in Canada are insufficient to develop conclusions regarding potential future trends in tornado activity near the Project site. Under the current understanding of climate change effects on the annual probability of tornadoes, tornado occurrences are not expected to change significantly (Brooks, Carbin and Marsh. 2014) (Tippett 2016). However, this conclusion is subject to high uncertainty as there is no evidence indicating either an increase or decrease in event frequency or intensity.

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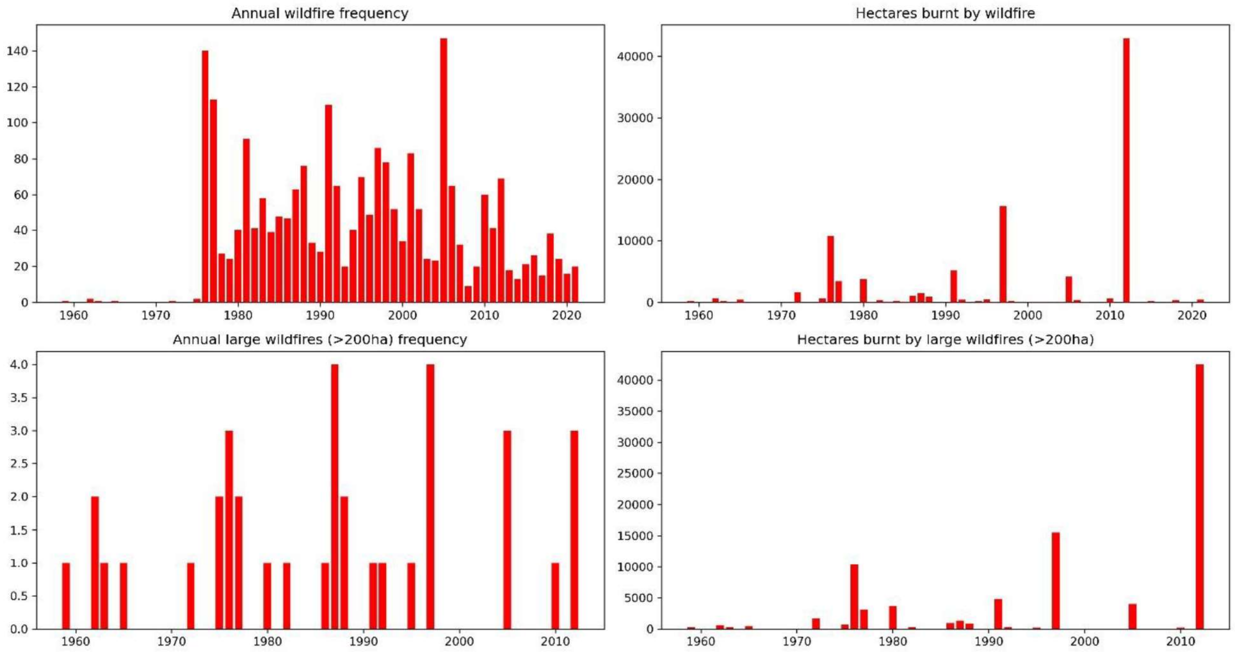
[4] The Northern Tornadoes Project (NTP) - Western University (uwo.ca)

6 Wildfires

On average from 1970 to 2017, 8000 wildfires occurred across Canada annually (Canadian Forest Service 2022). However, few are deemed as a disaster and the majority are managed and result in no or few negative impacts. For this assessment, the hazard threshold is defined as the occurrence of large fires (≥ 200 hectares [ha]) within 100 km of the Project site. However, it is important to note that severe wildfires outside the 100 km radius can still affect the visibility and air quality of the region.

Using the Canadian Wildland Fire Information System (NRCan 2017), 36 large wildfires for the 1950-2020 period were observed within a 100 km radius of the Project site. Figure 18 shows the annual wildfire frequency and area burnt within 100 km of the Project site.

Figure 18 Number of Annual Wildfires and Area Burnt within 100 km of the Project (NRCan 2017)



Under the RCP8.5 climate change projections, the area burnt by wildfires is expected to increase gradually from 2020 to 2050 and exponentially from 2050 to 2100 (Balshi, et al. 2009). Due to the predicted warmer temperatures, change in precipitation, and intensification of drought events, fire occurrences caused by lightning are expected to increase by an estimated 24% by 2040 and by 90% by 2090 in Ontario based on fire weather and fuel moisture scenarios from GCM climate projections and the LEOPARDS protection analysis system (Wotton, Logan and McAlpine 2005). Temperature shows a strong positive correlation with lightning, humidity, and fire season; therefore, warmer temperatures may result in longer fire seasons and more frequent and intense wildfires. However, this conclusion is subject to a moderate amount of uncertainty due to the complex nature of wildfires, fuel type, and possible future fire management adaptation plans.

7 Severe Storms (Thunderstorms, Lightning, Winter Storms)

Severe thunderstorms producing lightning are a frequent occurrence in the region of Timmins. As severe thunderstorms can generate hail and tornadoes, and are usually accompanied by high winds, their impacts can vary for each storm. Historically, ECCC-issued severe thunderstorm warnings occur annually in the region. Unfortunately, due to the complex and localized nature of thunderstorms, identifying trends and measuring the influence of a warming climate on storm activity can be challenge. Additionally, due to their relatively small scale and the limitations on available historical data, GCMs are unable to precisely observe their impacts as climate change is also transforming the dynamics of systems. However, with increasing temperature and moisture in the atmosphere, there is an increased potential for future severe thunderstorms in the Timmins region.

The Canadian Lightning Activity Statistics recorded 13,679 cloud to ground lightning flashes from 1999 to 2018 with an annual average of 25.7 days with lightning within 25 km of Timmins. Under the impacts of climate change, a proxy model based on precipitation rates and air circulation in the atmosphere has estimated for every ~1°C increase in global average air temperature, there is a 12% (±5%) increase of lightning in the US due to higher moisture content in the atmosphere (Romps, et al. 2014). However, this increase does not apply to all mid-latitude locations. While most studies report increases of 5 to 16% in lightning flashes using the cloud top height approach, their response to climate change remains highly uncertain due to challenges in estimating cloud ice content (Finney, et al. 2018). Given the disagreement in the current studies, further research is needed to evaluate lightning occurrence and its response to climate change.

Severe winter storms (blizzards, storms with blowing snow) occur annually in the Timmins region, often significantly impacting road conditions and local traffic. Under a warming climate, snowfall in extreme winter storms is expected to decrease, transforming into liquid precipitation. Using a pseudo-global warming approach, future projections under a warming climate scenario suggest that an increase in temperature and moisture will likely shift extreme snowstorm northward of the US-Canada border, while the intensity of heavy snowfall events is projected to remain relatively constant (McCray, et al. 2023).

8 Drought

Drought can cause major agriculture, economic, and environmental damage. As effects are only apparent after a long period of dry conditions, it is generally difficult to determine drought onset, extent, and end. Canada has experienced frequent and severe droughts over its history, especially in the western regions. However, under the impacts of climate change, new areas across the country may be affected and recurring severe droughts are expected to occur more often.

To quantitatively measure and project the magnitude, duration, and spatial extent of droughts, the Standardized Precipitation Evapotranspiration Index (SPEI) is considered. Using metrics such as precipitation, runoff rates, evapotranspiration, and soil water content over an extended time period, the SPEI can monitor and analyze droughts and identify their characteristics in the context of climate change. A SPEI value greater than 1 is considered a wet state while a value less than or equal to -1 is considered a dry state. Figure 19 and Figure 20 shows the historical and projected 3-month and 12-month SPEI near the Project site, respectively. The 3-month SPEI is generally used to assess short-term conditions as changes in precipitation patterns, soil moisture and seasonal changes, while the 12-month SPEI can evaluate the water table and long-term conditions.

Under the RCP8.5 climate change scenario, the projected 3-month SPEI becomes increasing dry and wet after the 2050s. This can be attributed to heightened instability caused by climate change in the region and increased uncertainty in the long-term model projection. For the 12-month SPEI, wet periods become exceedingly rare after the 2050s, suggesting a prolonged dry conditions with occasional droughts. The long-term dry conditions can be attributed to deficit in the water balance, caused by prolonged increased evapotranspiration, runoffs, and lower soil moisture.

Figure 19 Historical and Projected 3-Month SPEI Near the Project Site (1900-2100)

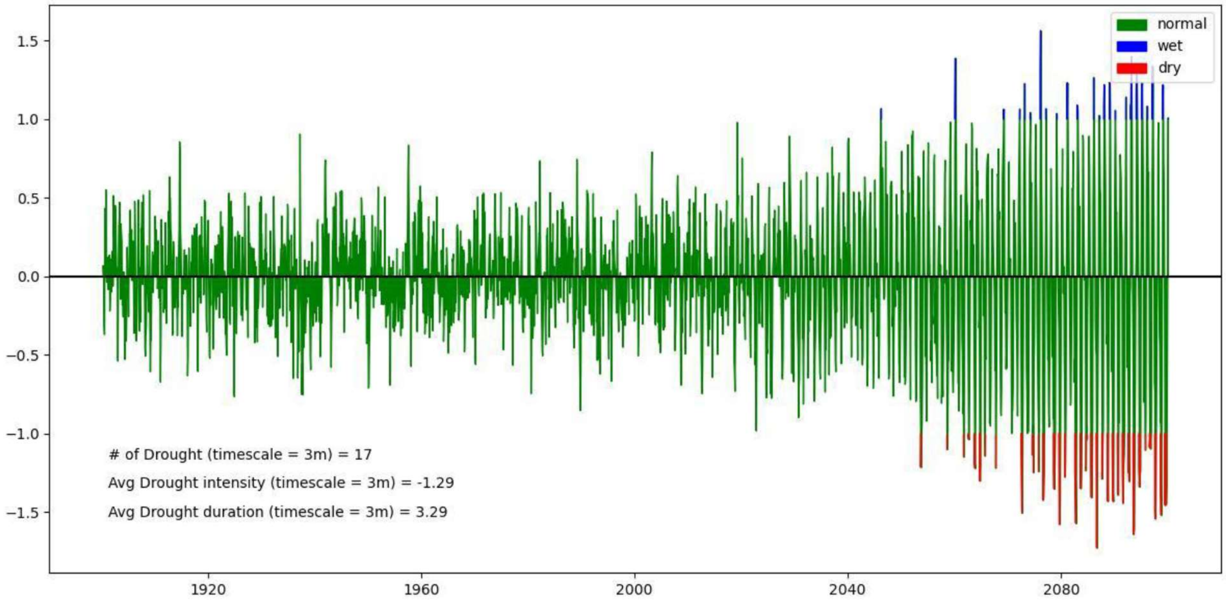
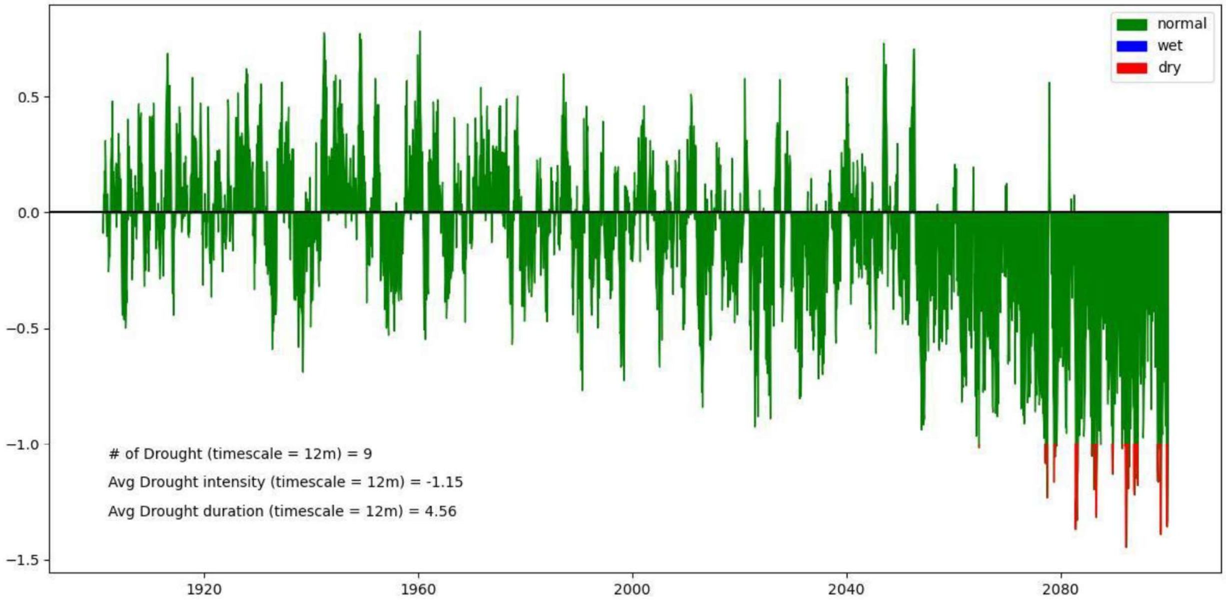


Figure 20 Historical and Projected 12-Month SPEI Near the Project Site (1900-2100)



9 Inversions

Atmospheric inversions are layers in the atmosphere where the air temperature increases with height (Heidinger, et al. 2018), in contrast to normal conditions, where warmer air masses are closer to the ground. Inversion often occurs near valleys sheltered by the wind and during late afternoon or early evening and lasts until a few hours after sunrise, as the ground warms up the surface air. During inversion, the stable cold/warm air configuration traps smoke and pollutants at the ground level and reduces vertical mixing in the atmosphere.

In an open pit mine, inversion can affect surface mine environments in the form high concentrations of gases and dusts, which accumulate at the ground level as a result of increased air overpressure and ground vibrations, and the prevention of gas dispersion (Tukkaraja, Keerthipati and French 2016). As inversion develops, the cold air masses will start to sink due to gravitational pull, increasing in density and thus, reducing air and pollutant transfer in the affected area. Studies comparing the 1951-1980 and the 1981-2010 periods have shown that atmospheric inversions are occurring more frequently under a warmer climate. A warmer climate is expected to increase evapotranspiration, releasing more latent heat in the upper troposphere, which could reduce the temperature lapse rate in the troposphere with the strongest increase in summer, especially over the mid-latitudinal continental Northern Hemisphere (Hou and Wu 2016).

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