Appendix C

Alectra Value Framework Definition Document

2024

Alectra Utilities Value Framework Definition Document

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Statement of Confidentiality

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1 Introduction

The following Value Framework Definition Document is intended to capture the information needed to specify the risk mitigation and benefit values associated with Investments in Alectra Utilities Value Framework. This document also captures the relevant processes, methodologies and key assumptions that were used to develop the Value Framework. This document will also, briefly, review how the Value Framework is used to evaluate Investments and arrive at optimized recommendations.

2 Value-Based Decision-Making

2.1 Introduction to Value-Based Decision-Making

For an organization to optimize the use of its limited resources, it must have a mechanism to determine the relative value of each Investment. The following elements can contribute to the overall value of an Investment:

- Risks mitigated by an Investment
- Consequences of a given risk, if they're not mitigated
- Financial impacts, such as cost savings
- Overall cost of the Investment
- Impacts to Key Performance Indicators (KPIs)
- Service measures
- Overall organizational value adds

An Investment's net value is then used to determine both its independent merit and its standing among other Investments competing for resources in a constrained Optimization process. The process used to generate the Value Framework captured in this document is called Value-Based Decision-Making (VDM) and is an implementation of Multi-Criteria Decision Analysis (MCDA). The VDM approach (Figure 1. Value-Based Decision-Making Approach) is a best practice in Asset Investment Planning and Management (AIPM) and encourages organizations to:

- Use a value-based approach to guide the development of the decision criteria and the relative weighting of the criteria to one another.
- Use a rational economic approach calibrated to a common scale so that dissimilar Investments can be compared based on a wide range of criteria.
- Align these criteria to the objectives and values of the organization to ensure that higher value translates into more success for the organization sooner.
- Use a quantitative, consistent, and repeatable approach to assess all benefits.
- Use a risk-informed approach, made by constructing an appropriate Risk Matrix to align the mitigation of risk to the common scale, ensuring risk is factored into decision-making.
- Ensure that both financial and non-financial benefits are included, and that their contributions are aligned to the common scale.

The VDM approach can be simplified into two primary activities:

- Develop a unique Value Framework that captures the organization`s key Value Measures, financial parameters, and Risk Matrix, and is aligned with the overall organizational goals.
- Use the Value Framework to evaluate and optimize potential Investments.

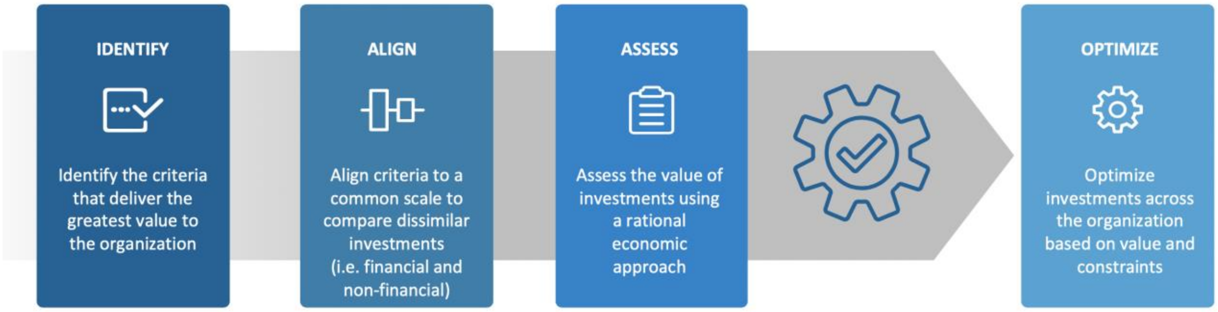


Figure 1: Value-Based Decision-Making Approach

The Copperleaf Value Framework (Figure 2: Copperleaf Value Framework) begins with the organization's strategic objectives and the scope of the Investments being considered. These guide the definition of Value Measures, Risk Matrix, and, ultimately, Value Function. It also defines and documents the financial parameters to be used in evaluating Investments, as well as any detailed supporting calculations, supporting processes, and related assumptions.

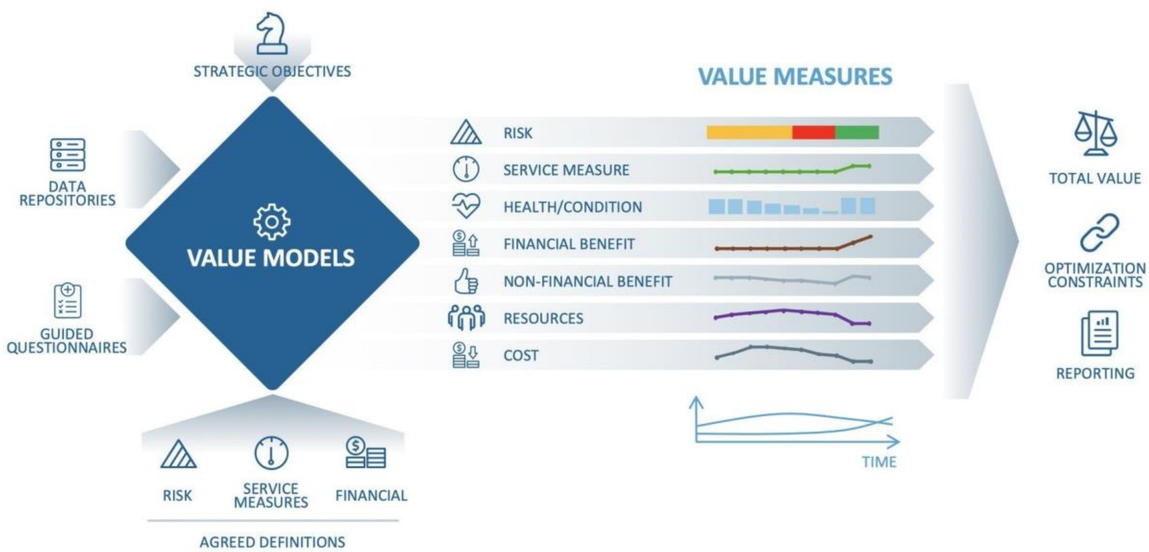


Figure 2: Copperleaf Value Framework

2.2 Value Measure Types and Criteria

Value Measures used at Alectra Utilities can be classified into four main types:

- **Condition Value Measures** are used to capture the health of an Asset and are typically used as inputs to other Value Measures (for example, to calculate the probability of failure of an Asset) and for reporting.

- **Risk Value Measures** are typically configured with a baseline and an outcome calculation and are mainly used to capture the value of an Investment in avoiding undesirable events. For example, an Investment might be targeted to reduce safety and reliability consequences linked to the in-service failure of an Asset. Risk mitigation is typically included in the Value Function as a positive contributor to Investment Value.
- **Benefits** capture desirable outcomes that are created by an Investment, such as improvements in revenue or Client service. As with all Value Measures, Benefits may be configured to have both a baseline and an outcome, but it is typical for a Benefit Value Measure to have only an outcome. Benefits are typically included in the Value Function as a positive contributor to Investment Value.
- **Cost Value Measures** represent the money that must be spent to execute the Investment. There is an Investment Cost Value Measure that is used as a negative contributor to Investment Value. Then there are Value Measures that represent the breakdown of the Investment Cost into individual Account Types that can be used as Constraints, and for reporting (Capital Spend or O&M Spend). These measures are not typically included in the Value Function as they would duplicate the Value expressed by the Total Cost Value Measure.

2.3 Assessing and Optimizing Investments

The Value Function combines all the required Value Measures to assess and compute the overall value that each Investment is bringing to the organization, taking into account its financial and non-financial benefits, Risk Mitigation, and cost. All Investments are then optimized automatically by selecting the combination of start dates and Investment Alternatives that will bring the highest total value to the organization while satisfying financial, resource, service measure, and timing constraints.

While each Investment may bring value to the organization, it's not until the Investments are compared to one another, and financial constraints are applied, that it is known whether a specific Investment will be funded or not, and in what timeframe. A lower value Investment may be delayed in lieu of other, more urgent Investments, or it may ultimately be deemed unnecessary. Conversely, a lower value Investment may be expedited if it is the only feasible option remaining, after most funds have been allocated to higher value projects.

Decisions about which Investments should be funded and when, are made using Copperleaf Portfolio's Optimization module. A full description of its functionality is beyond the scope of this document. For further details, consult the resources relating to the Optimization module, or contact Copperleaf directly.

Independent of the role that value plays within Optimization, it is often useful to see the value of an Investment. This is represented by various financial metrics, which can be attached to portfolios or included in reports. The following are some of the most useful metrics to help determine the relative value of Investments:

- **Value**: The net value of the Investment, as well as the breakdown of components making up that value is visible to the Investment owner. An Investment with a net value less than zero is an Investment in which all the benefits specified for the Investment have a present value less than the present value of the cost. Investments with a net value less than zero should be reconsidered (for example, if this Investment is required for compliance reasons but has a negative value, that may indicate that the Compliance Risk has been misestimated) and/or re-evaluated for other value opportunities.
- **Value/$**: An Investment with a larger net value is bringing more value to the organization; however, larger Investments typically bring more value than smaller Investments. Therefore, Value/$, (that is,

net value/cost of the Investment) can help to compare the effectiveness of Investments of different sizes.

For more details on financial metrics and reporting, consult the documentation on those topics, or contact Copperleaf directly.

3 Organizational Objectives

This section outlines the organizational objectives for Alectra Utilities.

3.1 Strategic Objectives and Value Measures

Alectra Utilities has eight key strategies to which all the identified Value Drivers roll up:

- Financial
- Reliability
- Safety & Security
- Regulatory & Compliance
- Customer Service
- Environmental
- Public & Employee Perception
- Innovation & Technology

3.1.1 Value Drivers and Value Measures

Eight Value Drivers have been identified. These represent categories or areas where value can be created by Capital Investments which support the Strategic Objectives:

- Financial
- Reliability
- Safety & Security
- Regulatory & Compliance
- Customer Service
- Environmental
- Public & Employee Perception
- Innovation & Technology

Each Value Driver is comprised of one or more Value Measures. Value Measures are the specific attributes of an Investment that will be evaluated to objectively determine how the Investment delivers value to Alectra Utilities, and to place that value on a common economic scale. The following sections detail the Value Measures for each Value Driver as well as the Value Models that are used to calculate them.

3.1.2 Strategic Objectives Details

The follow sections detail the Strategic Objectives.

3.1.2.1 Financial

3.1.2.1.1 Value Drivers and Value Measures

The Financial objective Value Drivers and their associated Value Measures.

Financial

- Capital Financial Benefit
- Financial Risk
- Future Revenue
- OM&A Financial Benefit

3.1.2.2 Reliability

3.1.2.2.1 Value Drivers and Value Measures

The Reliability objective Value Drivers and their associated Value Measures.

Reliability

- Distribution System Capacity Risk
- Reliability Benefit
- Reliability for Spares Benefit

3.1.2.3 Safety & Security

3.1.2.3.1 Value Drivers and Value Measures

The Safety & Security objective Value Drivers and their associated Value Measures.

Safety & Security

- Cyber Security Risk
- Safety Risk
- Cyber Security Benefit

3.1.2.4 Regulatory & Compliance

3.1.2.4.1 Value Drivers and Value Measures

The Regulatory & Compliance objective Value Drivers and their associated Value Measures.

Regulatory & Compliance

- Compliance Risk
- Rate Ready Organization Benefit

3.1.2.5 Customer Service

3.1.2.5.1 Value Drivers and Value Measures

The Customer Service objective Value Drivers and their associated Value Measures.

Customer Service

- Customer Communication Benefit
- Customer Centricity
- Customer Service Benefit

3.1.2.6 Environmental

3.1.2.6.1 Value Drivers and Value Measures

The Environmental objective Value Drivers and their associated Value Measures.

Environmental

- Environmental Improvements Benefit
- Environmental Risk

3.1.2.7 Public & Employee Perception

3.1.2.7.1 Value Drivers and Value Measures

The Public & Employee Perception objective Value Drivers and their associated Value Measures.

Public & Employee Perception

- Employee Wellness Benefit
- Reputational Risk

3.1.2.8 Innovation & Technology

3.1.2.8.1 Value Drivers and Value Measures

The Innovation & Technology objective Value Drivers and their associated Value Measures.

Innovation & Technology

- IT Capacity Risk
- Data Collection, Sharing and Reuse
- Technological Innovation Benefit

- IT Technical Risk

4 Risk Matrix

As described above, Risk is defined as the probability of an event occurring multiplied by the Consequence of that event. The Risk Matrix is built around the risk types that are important to the organization (that is, safety, environmental, lost production, etc.) and the associated Consequences by severity level. It is essential that the Consequence levels are aligned across the different risk types.

The Investment owner specifies:

- Baseline Risk: The risk present if the Investment is not completed.
- Residual Risk: The risk present after the Investment is completed.

Value of Risk Mitigated is computed as: Mitigated Risk = Baseline Risk – Residual Risk (Post-Investment Baseline Risk)

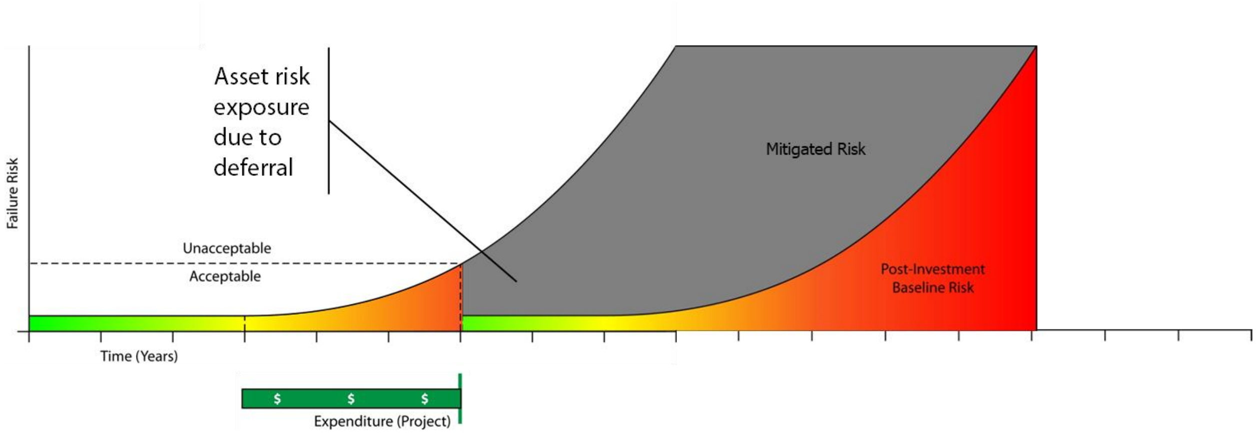


Figure 3: Mitigated Risk Over Time

Risks may be calculated automatically based on a combination of user entered data and Asset Attributes, or may be specified based on the Likelihood and Consequence levels defined in the Risk Matrix. When risks are specified using the Risk Matrix, the value of each risk is evaluated based on the definitions provided in Consequence Definition and Likelihood Definition sections of this document.

4.1 Consequence Definition

The definition of the Consequence levels was developed by first looking at the overall range of Consequences (usually starting with financial consequences). Once the range was established, Consequence levels are created such that each level increases non-linearly (usually between 3x to 10x increase per level). This provides a clear progression between levels where changing a Consequence level results in a meaningful, conclusive change.

Existing Alectra Utilities risk Consequences were aligned with the more granular Consequence levels to provide flexibility for Investment risk evaluation.

4.1.1 Consequence Levels

Attributes	None	Impact 150	Impact 500	Impact 1,500	Impact 4,500	Impact 7,500	Impact 12,500	Impact 30,000
Default Description								
Maximum Value	149	499	1499	4499	7499	12499	29999	50000
Minimum Value	0	149	499	1499	4499	7499	12499	29999
Average Value	0	150	500	1500	4500	7500	12500	30000

Table 1: Consequence Levels

4.1.2 Consequence Definitions

Consequence	None	Impact 150	Impact 500	Impact 1,500	Impact 4,500	Impact 7,500	Impact 12,500	Impact 30,000
Cyber Security Risk	None: no cyber security risk detected	N/A	No amount of information is withdrawn / lost; no system impact to end-users	Small amount of non-sensitive information is withdrawn / lost; lost system efficiency to end-users; time/cost to recovery with existing resources	Moderate amount of non-sensitive information / small amount of sensitive information is withdrawn / lost; lost access to non-critical systems to end-users; time/cost to recovery require additional resources	N/A	Moderate amount of sensitive information is withdrawn / lost; lost access to critical systems to subset of end-users; time/cost to recovery is unpredictable but can be remedied with additional resources	Large amount of sensitive information is withdrawn / lost; lost access to some critical systems to all end-users; time/cost to recovery is not possible
Distribution System Capacity Risk	Threat: Able to supply load without exceeding planning limits	N/A	Threat: Can supply all load but temporarily exceeding planning limits	Threat: Can supply all load but there is sustained operation exceeding planning limits	Threat: Can supply all load but exceeding thermal limits	N/A	Threat: Unable to service a new load or mandated upgrades required to be completed on the transmission system	N/A

Consequence	None	Impact 150	Impact 500	Impact 1,500	Impact 4,500	Impact 7,500	Impact 12,500	Impact 30,000
							to meet Regional Planning directives.	
Environmental Risk	No noticeable impacts with minor clean-up implications	Known impacts contained to the worksite such as fugitive emissions, minor spills with short term (< 1 year) clean-up implications	Known impacts contained to the worksite such as fugitive emissions, minor spills with medium term (up to 2 years) clean-up implications	Impacts with medium term (2 to 5 years) cleanup implications that are contained to the worksite	Impacts are long term (>5 years) and are not contained on the worksite resulting in potential loss of flora, fauna and/or fish habitat. Impact significant enough to gain attention in provincial news media	N/A	Impacts cause long term (> 20 years) damage to a water body, an environmentally/culturally sensitive receptor resulting in actual loss of flora, fauna or fish habitat. Impact significant enough to gain attention in national news media	N/A
Financial Risk	Threat/Opportunity: Immaterial financial impact	Threat/Opportunity: Financial impact of an event up to $300,000	Threat/Opportunity: Financial impact of an event $300,000 to $1,000,000	Threat/Opportunity: Financial impact of an event $1,000,000 to $3,000,000	Threat/Opportunity: Financial impact of an event $3,000,000 to $5,000,000	Threat/Opportunity: Financial impact of an event $5,000,000 to $10,000,000	Threat/Opportunity: Financial impact of an event $10,000,000 to $15,000,000	Threat/Opportunity: Financial impact an event over $15,000,000
IT Capacity Risk	Lack of capacity (or currency) of a system has no expected impact on Alectra's workforce	Lack of capacity (or currency) of system that impacts significantly (e.g. >10% average decrease in productivity) for more than 10 Alectra's employees	Lack of capacity (or currency) of system that impacts significantly (e.g. >10% average decrease in productivity) for more than 50 Alectras's employees.	Lack of capacity (or currency) of system that impacts significantly (e.g. >10% average decrease in productivity) for more than 150 Alectra's employees	Lack of capacity (or currency) of system that impacts significantly (e.g. >10% average decrease in productivity) for more than 450 Alectra's employees.	Lack of capacity (or currency) of system that impacts significantly (e.g. >10% average decrease in productivity) for more than 750 Alectra's employees	Lack of capacity (or currency) of an Enterprise wide system that impacts significantly (e.g. >10% average decrease in productivity) the entire Alectra's workforce.	N/A

Consequence	None	Impact 150	Impact 500	Impact 1,500	Impact 4,500	Impact 7,500	Impact 12,500	Impact 30,000
Reputational Risk	Immaterial consequence which does not garner media coverage.	Localized issue involving direct to customer(s) or stakeholder(s) communications and easily resolved.	Adverse local/community media or social media coverage. Organized stakeholder pressure to the company.	Adverse regional coverage, one or more media types.	Adverse regional coverage, one or more media types. Multi-channel stakeholder pressure through call-centre, Board or executive channels.	Adverse national coverage, multiple media types with wide reach (e.g., news/publications, radio, social media channels.	Adverse national coverage, multiple media types with wide reach (e.g., news/publications, radio, social media channels). Multi-channel stakeholder pressure through call-centre, Board or executive channels.	Sustained, adverse national media coverage with adverse impact to community stakeholders. Shifting public opinion and negatively impacting company morale with multi-channel stakeholder pressure that is rapid and sustained (multi-day/week).
Safety Risk	Insignificant/ Negligible impact on staff and public safety	Impact of event requires additional actions than routine activity. Reportable incident of minor injuries of staff or members of the public.	An event that cannot be managed under routine activity and requires some additional management time and focus. Risk of injury of staff or members of the public requiring medical attention.	An event that cannot be managed under routine activity and requires some additional management time and focus. Reportable incident of acute/ first-aid injuries of staff or members of the public but no lost time injuries.	A major event with a long recovery period that stretches plans to the limit and requires major management efforts to endure, or company efforts to remedy adverse effects on the public. Reportable incident with serious but non-life threatening injuries.	A major event with a long recovery period that stretches plans to the limit and requires major management efforts to endure. Reportable incident of chronic/ long-term injuries of staff/members of the public and/or disability	A fatal event that can lead to the collapse of the organization or significant damage to the public. Life threatening injuries with long-term health implications.	A fatal event that can lead to the collapse of the organization or significant damage to the public. Reportable incident of any loss of life.

Consequence	None	Impact 150	Impact 500	Impact 1,500	Impact 4,500	Impact 7,500	Impact 12,500	Impact 30,000
						(resulting in Lost Time Injuries)		

Table 2: Consequence Definitions

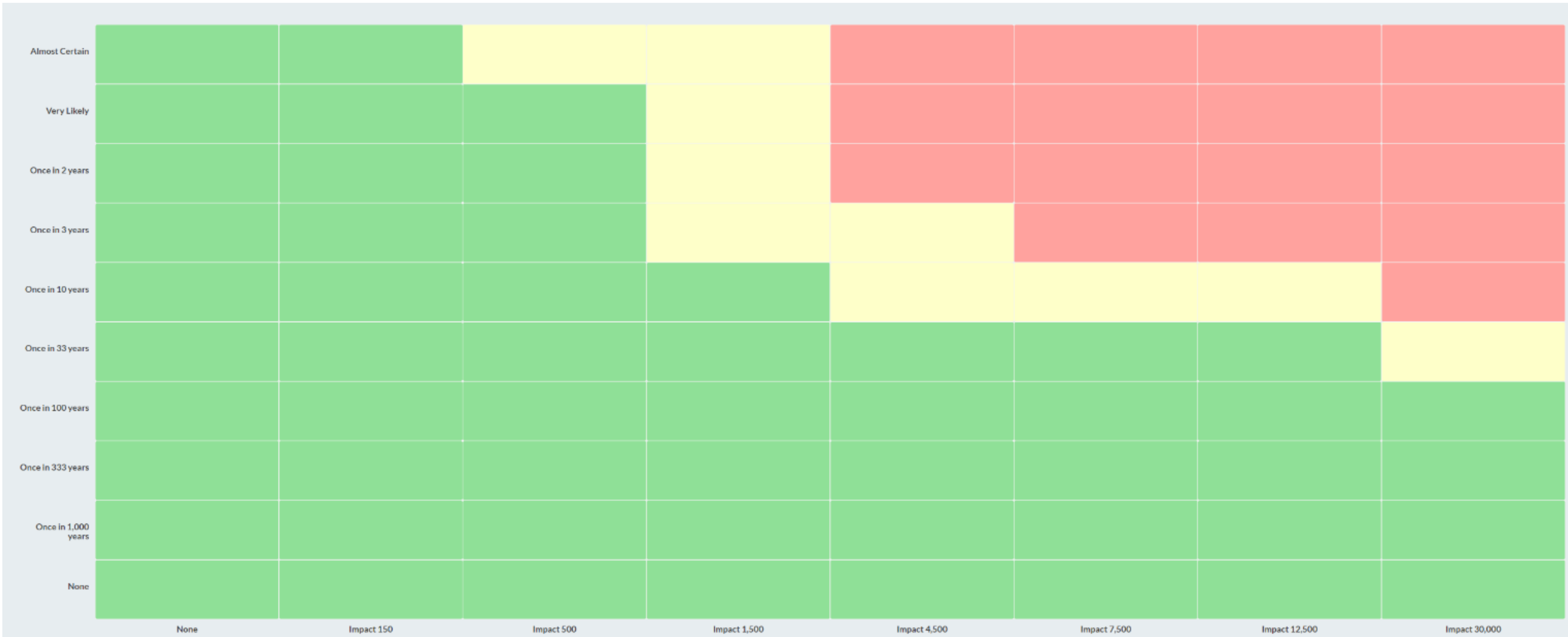
4.2 Likelihood Definition

The definition of Likelihood levels follows a similar principle to Consequence in order to get adequate differentiation between levels; however, the range doesn't need to be determined as it is between 0 and 100%. Again, an increase of 3x to 10x between levels is the norm. The types of risk events that are being considered may also impact the definitions of Likelihood levels.

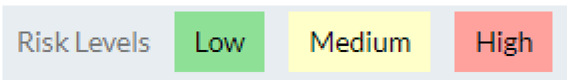
	None	Once in 1,000 years	Once in 333 years	Once in 100 years	Once in 33 years	Once in 10 years	Once in 3 years	Once in 2 years	Very Likely	Almost Certain
Description	Event unlikely to occur in next 1000 years	Approximately 0.1% chance of event occurring this year (e.g. 1 in 1000 year event)	Approximately 0.3% chance of event occurring this year (e.g. 1 in 333 year event)	Approximately 1% chance of event occurring this year (e.g. 1 in 100 year event)	Approximately 3% chance of event occurring this year (e.g. 1 in 33 year event)	Approximately 10% chance of event occurring this year (e.g. 1 in 10 year event)	Approximately 30% chance of event occurring this year (e.g. 1 in 3 year event)	Approximately 50% chance of event occurring this year (e.g. 1 in 2 year event)	Approximately 75% chance of event occurring this year (e.g. 1 in 1.3 year event)	Imminent (>95% chance of occurring this year)

Table 3: Likelihood Definitions

4.3 Risk Matrix



4.4 Risk Levels



4.5 Using the Risk Matrix for Calculation of Value Measure Output

For Value Models that calculate Value Measure Outputs using a probability and consequence value from the Risk Matrix, a specific questionnaire has been created. This questionnaire is a **Manual Risk questionnaire (named accordingly for each Risk Matrix Value Model) e.g. Compliance Risk Questionnaire for Compliance Risk.**

The user is prompted to answer the following questions in the **Manual Risk** questionnaire:

Variable Prompt	Description	Time Varying?	Selection Options
Risk Consequence	What is the consequence of this event occurring?	YES	Dropdown - Risk Matrix Consequence
Risk Probability	What is the probability of this event occurring?	YES	Dropdown - Risk Matrix Probability
Provide any rationale or assumptions for the answers provided	Provide background information justifying selection of answers	NO	Max 10,000 characters expanded Text-box

Table 4: Manual Risk Questionnaire

The user chooses the appropriate probability, consequence levels and frequency based on the definitions shown in the Consequence Definitions section of this document.

The Investment is expected to reduce either the probability of the event, the consequence of the event, or both. This risk is calculated directly in value units using the Risk Matrix model described in the Risk Matrix section.

For both the baseline and the outcome values, risk is calculated as:

Risk = Risk Consequence * Risk Probability

By default, the system will assume the risk is fully mitigated to a value of zero from the month following the last month of the Investment with spend. This behavior uses a default **Automated Risk Mitigation** questionnaire selection which has no user inputs.

If the user wishes to override this default behavior and specify an outcome risk profile or a non-default impact date, they may use the questionnaire described above.

The Mitigated Risk value generated for the measure annually is equal to:

Risk Value = Baseline Risk - Outcome Risk

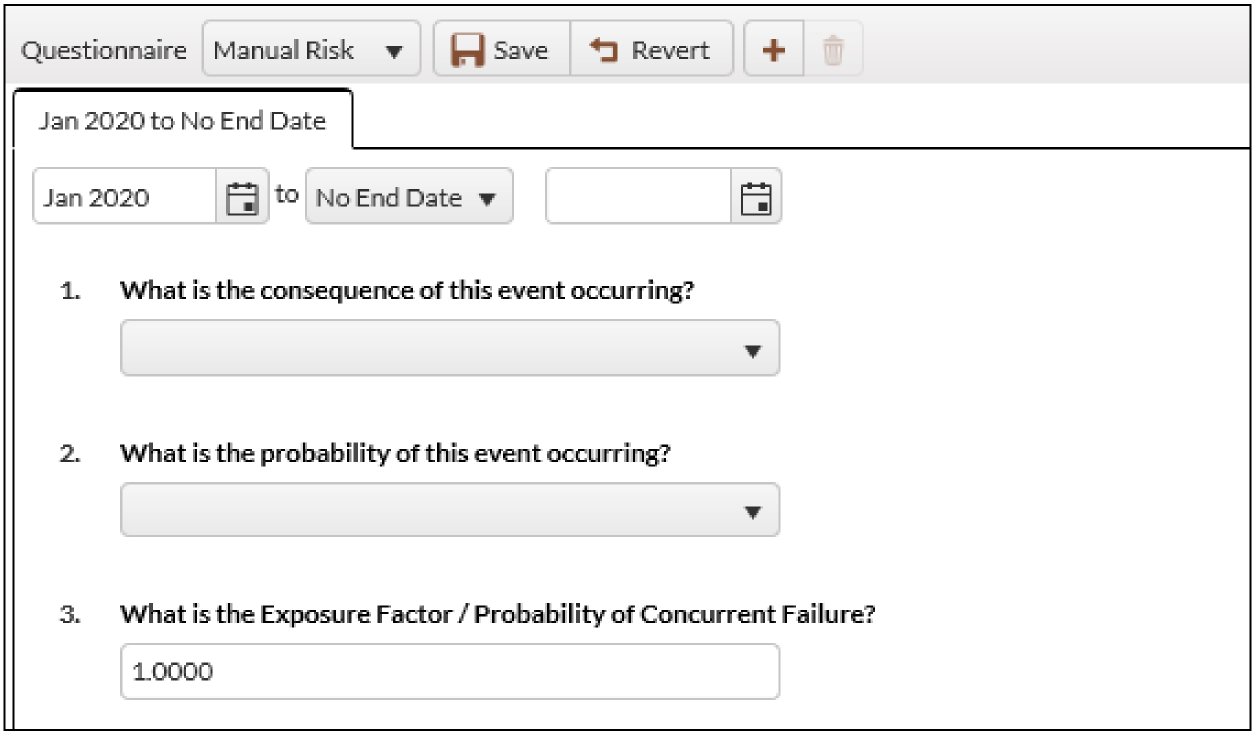


Figure 4: Manual Risk Questionnaire

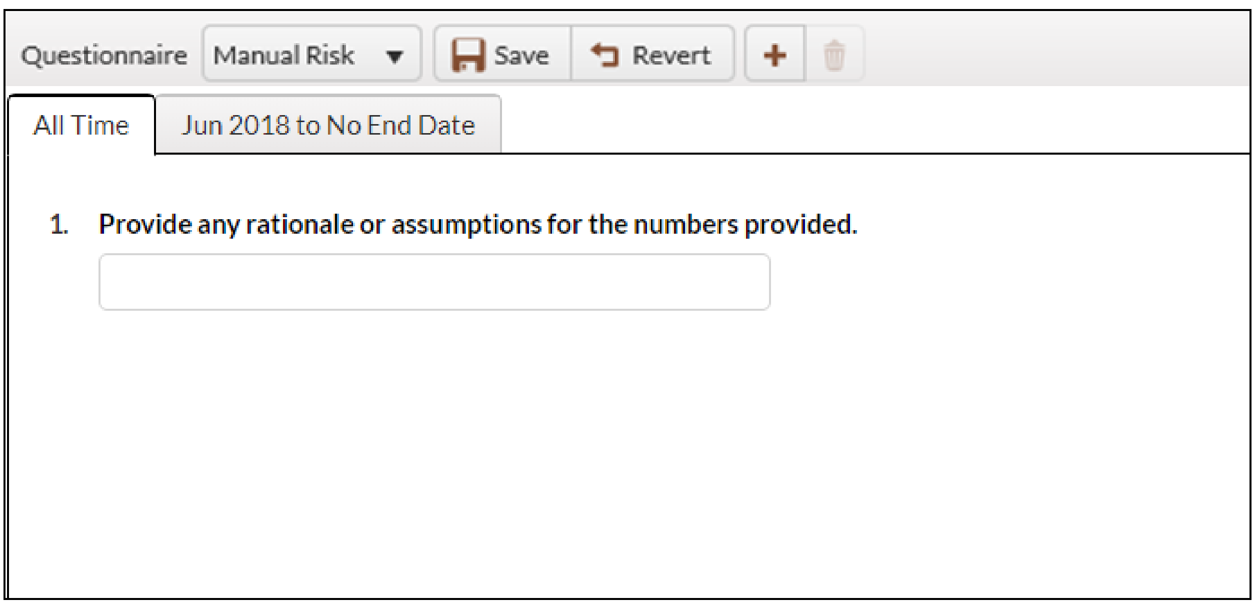


Figure 5: Manual Risk Rationale

5 Value Models and Value Measures

Whereas Value Measures cover the different types of value that a given Investment can bring to the organization, Value Models capture the way in which these Measures are calculated.

A Value Model can be used to calculate one or more Value Measures as shown in the figure below:

Figure 6: Value Models and Value Measures

As displayed above, some Value Models are driven by preexisting data in the system, while others require manual data entry into a Questionnaire. Some Questionnaires may ask for inputs relating to the matrix, while others may include a more complex set of questions that feeds a calculation. All approaches are discussed in the following sections. The following tables provide a summary of the Value Models and their corresponding Value Measure outputs.

Value Model Groups

Benefits

Value Model	Usage	Output Value Measures
Capital Financial Benefit	Optional	• Capital Financial Benefit
Customer Centricity	Optional	• Customer Centricity
Customer Communication Benefit	Optional	• Customer Communication Benefit
Customer Service Benefit	Optional	• Customer Service Benefit
Employee Wellness Benefit	Optional	• Employee Wellness Benefit
Environmental Improvements Benefit	Optional	• Environmental Improvements Benefit
OM&A Financial Benefit	Optional	• OM&A Financial Benefit
Rate Ready Organization Benefit	Optional	• Rate Ready Organization Benefit

Value Model	Usage	Output Value Measures
Reliability Benefit	Optional	• Reliability Benefit
Reliability for Spares Benefit	Optional	• Reliability for Spares Benefit
Technological Innovation Benefit	Optional	• Technological Innovation Benefit

Table 5: Summary of Value Models in the Benefits Group and their Output Value Measures

Costs

Value Model	Usage	Output Value Measures
Cost	Mandatory	• Investment Cost Capital • Investment Cost OPEX • Investment Cost
Future Revenue	Optional	• Future Revenue • Future Revenue Total

Table 6: Summary of Value Models in the Costs Group and their Output Value Measures

IT

Value Model	Usage	Output Value Measures
Cyber Security Benefit	Optional	• Cyber Security Benefit
Cyber Security Complex	Optional	• Cyber Security Risk
Data Reuse Benefit	Optional	• Data Collection, Sharing and Reuse
IT Capacity Risk	Optional	• IT Capacity Risk
IT Technical Risk	Optional	• IT Technical Risk

Table 7: Summary of Value Models in the IT Group and their Output Value Measures

Risks

Value Model	Usage	Output Value Measures
Compliance Risk	Optional	• Compliance Risk
Distribution System Capacity Risk	Optional	• Distribution System Capacity Risk
Environmental Risk	Optional	• Environmental Risk
Financial Risk	Optional	• Financial Risk
PA Results	Optional	• Financial Risk • Safety Risk • Reliability Risk • Environmental Risk
Reputational Risk	Optional	• Reputational Risk
Safety Risk	Optional	• Safety Risk

Table 8: Summary of Value Models in the Risks Group and their Output Value Measures

5.1 Value Measure and Value Model Types

5.1.1 Value Measures and Units

Value Measures may be calculated in any unit. For Value Measures to be included in a Value Function, a conversion is made between the units used for the Value Measure and the standard Value Units that are used in the Risk Matrix and in all Value calculations.

At Alectra Utilities, all Value Measures used in a Value Function are calculated either directly in Value Units (Risk Matrix-based Value Models) or in Canadian Dollar. Any models that are computed in Canadian Dollar have a conversion factor of 1:1000 applied to normalize it to the Value Measure scale.

5.1.2 Baselines and Outcomes

Value Measures may be configured either to measure a change in Value created by an Investment, or the absolute Value that exists after the Investment has been completed.

For example, risk mitigation is typically measured as the delta between the risk without the Investment (baseline risk) and the outcome or residual risk after the Investment is completed. For Value Measures such as Investment Cost, only the outcome after Investment completion is relevant as there is no baseline to be considered.

5.1.3 Use of Value Models

As described above, Value Models can be designated as either “mandatory” or “optional” for Assets or Investments, or both. This allows the system to automatically add certain Value Models such as Investment Cost or Asset Risk to all Investments, or to all Assets of a given Asset Type.

5.1.4 Time Varying Values

All Value Measures are calculated as streams of value over time. The System and Questionnaire inputs used in calculation may be defined as either fixed or varying over the time period. For example, the Asset Type of an Asset is a value that does not change over time, while the Probability of Failure of that same Asset may be specified to increase over time as the Asset ages.

5.2 Investment Models

The Value Models discussed in this section are models that are not mandatory for, and therefore not automatically added to, either Assets or Investments.

A user may add any of the Value Models in this section to an Investment. Additionally, a user may add any of the Value Models in this section to an asset, except the Avoided Future Asset Replacement which is tied to investment spend.

5.2.1 Benefits

5.2.1.1 Capital Financial Benefit

Capital Financial Benefit is used to measure Capital savings such as labour cost saving, productivity improvements, and other capital cost savings. Financial Benefit Type variable determines whether the savings would result in the tangible future cost reduction (Expected Reduction), cost avoidance (Avoided Cost) or productivity improvement (Efficiency Benefit).

5.2.1.1.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

Capital Financial Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Capital Financial Benefit Value Model.

Capital Financial Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Financial Benefit Type	Dropdown List	Yes	CapFinBen_TYPE	Financial Benefit Type	
Inside Labour Savings (hours per year)	Number (1 decimal place)	Yes	CapFinBen_LABH	Inside Labour Savings (hours per year)	
Outside Labour Savings (hours per year)	Number (1 decimal place)	Yes	CapFinBen_OLAB	Outside Labour Savings (hours per year)	
Other Capital Cost Savings (dollars per year)	Number (0 decimal places)	Yes	CapFinBen_COST	Other Capital Cost Savings (dollars per year)	
Probability of Benefit Achievement for Avoided Cost and Efficiency Benefits (Assume 100% for Expected Reduction) (%)	Number (2 decimal places)	Yes	CapFinBen_PROB	Enter a Value between 0-100 for Avoided Cost and Efficiency Benefit, enter 100 for Expected Reduction	
Type of Other Capital Cost Savings	Dropdown List	Yes	CapFinBen_TYCO	Type of Other Capital Cost Savings	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	CapFinBen_TEXT		

Table 9: Capital Financial Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
Financial Benefit Type	• Avoided Cost [redacted] • Efficiency Benefit [redacted] • Expected Reduction [redacted]
Type of Other Capital Cost Savings	• Contract • Materials • Not Applicable • Other • Revenue

Table 10: Capital Financial Benefit Questionnaires Dropdown List Details

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.1.2 Value Model Outputs

The **Capital Financial Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Capital Financial Benefit	Optional	• Capital Financial Benefit

Table 12: Capital Financial Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Examples of Benefit Types

Expected Reduction benefit type: This benefit type measures a tangible reduction that can be applied to future budget. For example, a change to the project is made such that services of an outside contractor are no longer needed. Therefore, the contractor position can be eliminated saving Alectra the cost of the contractor. The budget for the years following the contractor elimination can be reduced by the amount saved.

Avoided Cost benefit type: This benefit type measures the potential expenditures that would be avoided as a result of the project. To reflect the uncertainty in measuring and achieving the avoided costs the probability factor can be applied. For example, the project targets installing automated digital fault detectors. The new equipment would save hours of crew time by reporting the exact location of faults that would otherwise have to be determined manually by Alectra crews. In this example the probability of realizing the benefit is 100% as it is certain that the equipment will automatically determine and report faulty information to the control.

Efficiency benefit type: This benefit type is aimed at measuring productivity improvements. To reflect the uncertainty in measuring and achieving productivity gains the probability factor can be applied. For example, new software can enable employees to perform their day-to-day tasks faster. The time savings can be utilized by the employees to perform additional tasks. For demonstration purposes, let's say that the probability of employees taking advantage of the time savings is 75% meaning that that 3/4 of the employees will become more productive as result of the project.

5.2.1.2 Customer Centricity

Customer Centricity measures the value of enhancements to the following three pillars: customer engagement, brand loyalty, and ease of interaction. Customer Centricity is computed directly in Value Units so the conversion factor for the value measure is 1.

5.2.1.2.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

Customer Centricity User Questionnaires

The user is prompted to answer the following Questionnaires for the Customer Centricity Value Model.

Customer Centricity - Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the expected reach of customer engagement improvement of this project?	Dropdown List	Yes	CustomerEngagement	Customer Engagement	
What is the probability of Customer Engagement being achieved?	Number (2 decimal places)	Yes	CustomerEngagementProbability	Answer in integers between 0-100	
What is the expected impact to Alectra's Customer Net Promoter Score?	Dropdown List	Yes	NetPromoterScoreImpact		
What is the probability of Net Promoter Score being achieved?	Number (2 decimal places)	Yes	NetPromoterScoreProbability	Answer in integers between 0-100	
What is the expected impact to Alectra's Customer Net Supporter Score?	Dropdown List	Yes	NetSupporterScoreImpact		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the probability of Net Supporter Score being achieved?	Number (2 decimal places)	Yes	NetSupporterScoreProbability	Answer in integers between 0-100	
What is the expected reach of the project to improve ease of interaction for customers?	Dropdown List	Yes	EaseOfInteraction		
What is the probability of Ease Of Interaction being achieved?	Number (2 decimal places)	Yes	EaseOfInteractionProbability	Answer in integers between 0-100	

Table 13a: Customer Centricity - Outcome Time Varying Questionnaire

Customer Centricity - Outcome - Time Invariant

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Provide a rationale or assumptions for the numbers provided.	Text	Yes	`RationaleTimeInvariant`		

Table 145b: Customer Centricity - Outcome Time Invariant Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
What is the expected reach of customer engagement improvement of this project?	• a) Improves Customer Engagement for over 75% of customers [redacted] • b) Improves Customer Engagement for between 50 and 75% of customers [redacted] • c) Improves Customer Engagement for between 25 and 50% of customers [redacted] • d) Improves Customer Engagement for between 5 and 25% of customers [redacted] • e) Improves Customer Engagement for less than 5% of customers [redacted]
What is the expected reach of the project to improve ease of interaction for customers?	• a) Improves Ease Of Interaction for over 75% of customers [redacted] • b) Improves Ease Of Interaction for between 50 and 75% of customers [redacted] • c) Improves Ease Of Interaction for between 25 and 50% of customers [redacted] • d) Improves Ease Of Interaction for between 5 and 25% of customers [redacted]

Measure Prompt	Dropdown (Value)
	• e) Improves Ease Of Interaction for less than 5% of customers [redacted]
What is the expected impact to Alectra's Customer Net Promoter Score?	• a) Significant increase [redacted] • b) Moderate increase [redacted] • c) No increase [redacted]
What is the expected impact to Alectra's Customer Net Supporter Score?	• a) Significant increase [redacted] • b) Moderate increase [redacted] • c) No increase [redacted]

Table 156: Customer Centricity Questionnaires Dropdown List Details

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.2.2 Value Model Outputs

The **Customer Centricity** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Customer Centricity	Optional	• Customer Centricity

Table 17: Customer Centricity Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

- [redacted]

[redacted]

- [redacted]

- [redacted]

- [redacted]
- [redacted]
- [redacted]

- [redacted]

- [redacted]

- [redacted]

[redacted] [redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

- [redacted]

5.2.1.3 Customer Communication Benefit

Customer Communication Benefit is used to assess the impact (positive % change) of the project on the customer satisfaction survey.

5.2.1.3.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

Customer Communication Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Customer Communication Benefit Value Model.

Customer Communication Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the expected impact of this project on the percentage of customers answering "Satisfied" or "Very Satisfied" on the next Utility Pulse Survey?	Dropdown List	Yes	ECC1	What is the expected impact of this project on the percentage of customers answering "Satisfied" or "Very Satisfied" on the next Utility Pulse Survey?	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	ECCText		

Table 18: Customer Communication Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
What is the expected impact of this project on the percentage of customers answering "Satisfied" or "Very Satisfied" on the next Utility Pulse Survey?	• No Impact [redacted] • Non-Measureable Positive Impact [redacted] • Positive Impact of 1 percentage point [redacted] • Positive Impact of 2 percentage points [redacted] • Positive Impact of 3 percentage points [redacted] • Positive Impact of 4 percentage points [redacted]

Measure Prompt	Dropdown (Value)
	• Positive Impact of 5 or more percentage points [redacted] • Positive Impact of less than 1 percentage point [redacted]

Table 19: Customer Communication Benefit Questionnaires Dropdown List Details

5.2.1.3.2 Value Model Outputs

The **Customer Communication Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Customer Communication Benefit	Optional	• Customer Communication Benefit

Table 20: Customer Communication Benefit Output Value Measures

[redacted]

5.2.1.4 Customer Service Benefit

Customer Service Benefit is used to assess the impact of a project on Service Quality Indicators (SQI).

5.2.1.4.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

Customer Service Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Customer Service Benefit Value Model.

Customer Service Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Percentage Improvement in New Connections SQI	Number (2 decimal places)	Yes	SQ01	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Appointments Scheduled SQI	Number (2 decimal places)	Yes	SQ02	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Appointments Met SQI	Number (2 decimal places)	Yes	SQ03	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Rescheduled Missed Appointments SQI	Number (2 decimal places)	Yes	SQ04	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Telephone Calls Answered Within Acceptable Time SQI	Number (2 decimal places)	Yes	SQ05	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Telephone Calls Abandon Rate SQI	Number (2 decimal places)	Yes	SQ06	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Written Response SQI	Number (2 decimal places)	Yes	SQ07	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Percentage Improvement in Emergency Response SQI	Number (2 decimal places)	Yes	SQ08	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Reconnection Performance Standards following disconnection for Non-Payment	Number (2 decimal places)	Yes	SQ09	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Percentage Improvement in Micro-embedded Generation Facility Connections on time	Number (2 decimal places)	Yes	SQ10	Enter 15% as 15. Enter negative impacts as negative integers (-10% as -10).	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	`SQText`		

Table 21: Customer Service Benefit - Outcome Time Varying Questionnaire

5.2.1.4.2 Value Model Outputs

The **Customer Service Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Customer Service Benefit	Optional	• Customer Service Benefit

Table 22: Customer Service Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

5.2.1.5 Employee Wellness Benefit

Employee Wellness Benefit is used to assess the improvement in physical wellness of Alectra employees.

5.2.1.5.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

Employee Wellness Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Employee Wellness Benefit Value Model.

Employee Wellness Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Does this project have a positive impact on an employee's ability to perform their job/job satisfaction/the	Dropdown List	Yes	EWMental		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
ease-of-use of tools available?					
How will the employees physical wellness be improved?	Dropdown List	Yes	EW1	Desc: How will the employees physical wellness be improved?	
What percentage of all Alectra employees will be improved by this project?	Number (1 decimal place)	Yes	EW2	Desc: What percentage of all Alectra employees will be improved by this project? Enter a value between 0-100.	
Does this project align with one of the 5 Alectra Cultural and Behavioural Commitments? If yes, select which value it most closely aligns to.	Dropdown List	No	`AlectraCBCs`		
Provide the rationale or assumptions for the answers provided above.	Text	Yes	`EWText`		

Table 23: Employee Wellness Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
How will the employees physical wellness be improved?	• Build awareness [redacted] • Eliminate injuries [redacted] • Mitigate injuries or improve employee comfort [redacted]
Does this project have a positive impact on an employee's ability to perform their job/job satisfaction/the ease-of-use of tools available?	• No [redacted] • Yes [redacted]
Does this project align with one of the 5 Alectra Cultural and Behavioural Commitments? If yes, select which value it most closely aligns to.	• Delivers What We Promise • Ensures Clarity and Focus • Is Customer Centric • Is One Team • Prioritizes Well-Being

Table 24: Employee Wellness Benefit Questionnaires Dropdown List Details

5.2.1.5.2 Value Model Outputs

The **Employee Wellness Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Employee Wellness Benefit	Optional	• Employee Wellness Benefit

Table 25: Employee Wellness Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

5.2.1.6 Environmental Improvements Benefit

Environmental Improvements Benefit measures the positive impact on the environment. It is used to measure improvements such value of CO_2 emission reduction and energy efficiency (MWh) savings.

5.2.1.6.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

Environmental Improvements Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Environmental Improvements Benefit Value Model.

Environmental Improvements Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Quantity of waste paper that will be reduced each year (sheets of standard size paper)	Number (2 decimal places)	Yes	EnvImp_EI1	Desc: Quantity of waste paper that will be reduced each year (sheets of standard size paper)	
Quantity of CO_2 Emissions to be reduced each year (tonnes)	Number (2 decimal places)	Yes	EnvImp_EI2	Desc: Quantity of CO_2 Emissions to be reduced each year (tonnes)	
Energy Saved (MWh) saved per year if project completed (Line Losses, Reduced Consumption)	Number (2 decimal places)	Yes	EnvImp_EI3	Desc: Energy Saved (MWh) saved per year if project completed (Line Losses, Reduced Consumption)	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	EnvImp_Text		

Table 26: Environmental Improvements Benefit - Outcome Time Varying Questionnaire

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.6.2 Value Model Outputs

The **Environmental Improvements Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Environmental Improvements Benefit	Optional	• Environmental Improvements Benefit

Table 28: Environmental Improvements Benefit Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

[redacted]

5.2.1.7 OM&A Financial Benefit

OM&A Financial Benefits is used to measure OM&A savings such as labour cost saving, productivity improvements, other OM&A cost savings. Financial Benefit Type variable determines whether the savings would result in the tangible future cost reduction (Expected Reduction), cost avoidance (Avoided Cost) or productivity improvement (Efficiency Benefit). This benefit is similar to Capital Financial only is targeted at OM&A expenditures.

5.2.1.7.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

OM&A Financial Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the OM&A Financial Benefit Value Model.

OMA Financial Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Financial Benefit Type	Dropdown List	Yes	FinBen_TYPE	Financial Benefit Type	
Inside Labour Savings (hours per year)	Number (1 decimal place)	Yes	FinBen_LABH	Inside Labour Savings (hours per year)	
Outside Labour Savings (hours per year)	Number (1 decimal place)	Yes	FinBen_OLAB	Outside Labour Savings (hours per year)	
Other OM&A Cost Savings (dollars per year)	Number (0 decimal places)	Yes	FinBen_COST	Other OM&A Cost Savings (dollars per year)	
Type of Other OM&A Cost Savings	Dropdown List	Yes	FinBen_TYCO	Type of Other OM&A Cost Savings	
Probability of Benefit Achievement for Avoided Cost and Efficiency Benefits (Assume 100% for Expected Reduction) (%)	Number (2 decimal places)	Yes	FinBen_PROB	Enter a Value between 0-100 for Avoided Cost and Efficiency Benefit, enter 100 for Expected Reduction	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	FinBen_TEXT		

Table 29: OM&A Financial Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
Type of Other OM&A Cost Savings	• Contract [redacted] • Materials [redacted] • Not Applicable [redacted]

Measure Prompt	Dropdown (Value)
	• Other [redacted]
Financial Benefit Type	• Avoided Cost [redacted] • Efficiency Benefit [redacted] • Expected Reduction [redacted]

Table 30: OM&A Financial Benefit Questionnaires Dropdown List Details

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.7.2 Value Model Outputs

The **OM&A Financial Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
OM&A Financial Benefit	Optional	• OM&A Financial Benefit

Table 32: OM&A Financial Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Examples of Benefit Types

Expected Reduction benefit type: This benefit type measures a tangible reduction that can be applied to future budget. For example, a change to the project is made such that services of an outside contractor are no longer needed. Therefore, the contractor position can be eliminated saving Alectra the cost of the contractor. The budget for the years following the contractor elimination can be reduced by the amount saved.

Avoided Cost benefit type: This benefit type measures the potential expenditures that would be avoided as a result of the project. To reflect the uncertainty in measuring and achieving the avoided costs the probability factor can be applied. For example, the project targets installing automated digital fault detectors. The new equipment would save hours of crew time by reporting the exact location of faults that would otherwise have to be determined manually by Alectra crews. In this example the probability of realizing the benefit is 100% as it is certain that the equipment will automatically determine and report faulty information to the control.

Efficiency benefit type: This benefit type is aimed at measuring productivity improvements. To reflect the uncertainty in measuring and achieving productivity gains the probability factor can be applied. For example, new software can enable employees to perform their day-to-day tasks faster. The time savings can be utilized by the employees to perform additional tasks. For demonstration purposes, let's say that the probability of employees taking advantage of the time savings is 75% meaning that that 3/4 of the employees will become more productive as result of the project.

5.2.1.8 Rate Ready Organization Benefit

Rate Ready Organization Benefit is aimed at measuring the increase in likelihood of Alectra rate application approval by the regulator.

5.2.1.8.1 VALUE MODEL INPUTS

Takes Inputs from:

- User Questionnaires

Rate Ready Organization Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Rate Ready Organization Benefit Value Model.

Rate Ready Organization Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
If the project is completed, what will be the impact on the ability to prepare/defend rate submission?	Dropdown List	Yes	RRO1	Desc: If the project is completed, what will be the impact on the ability to prepare/defend rate submission?	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	RROText		

Table 33: Rate Ready Organization Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
If the project is completed, what will be the impact on the ability to prepare/defend rate submission?	• No impact [redacted] • Will make it possible to prepare rate submission or significantly increase likelihood of approval [redacted]

Table 34: Rate Ready Organization Benefit Questionnaires Dropdown List Details

5.2.1.8.2 VALUE MODEL OUTPUTS

The **Rate Ready Organization Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Rate Ready Organization Benefit	Optional	• Rate Ready Organization Benefit

Table 35: Rate Ready Organization Benefit Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

5.2.1.9 Reliability Benefit

Reliability Benefit computes the societal cost of an outage to the customer, and is based on the variable: peak load lost, duration of the outage, duration for which redundancy is lost and the type of the customer affected. The inputs are outlined below. Additional reliability benefits are allocated to project which affects worst performing feeders which is in line with Alectra's mandate of improving the reliability for the worst performing areas.

5.2.1.9.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

Reliability Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Reliability Benefit Value Model.

Reliability Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
How many failures per year will be avoided by implementing this project?	Number (2 decimal places)	Yes	REL_FAIL	If there is only a small probability of a failure each year, enter the probability as a decimal (e.g. 5% chance of occurring in a year, enter as 0.05)	
For each of the failures what would be the expected Peak Lost Load (Connected KVA), or in the case of redundant equipment the Peak load at risk (KVA)	Number (2 decimal places)	Yes	REL_PEAK	For each of the failures what would be the expected Peak Lost Load (Connected KVA), or in the case of redundant equipment the Peak load at risk (KVA)	
What is the average duration of the outage caused by the failures? (hours)	Number (2 decimal places)	Yes	REL_DUR	What is the average duration of the outage caused by the failures? (hours)	
If this is redundant equipment and there is a failure, what is the duration of the period for which redundancy will be lost (hours)?	Number (2 decimal places)	Yes	REL_DURR	If this is redundant equipment and there is a failure, what is the duration of the period for which redundancy will be lost (hours)?	
What is the customer type?	Dropdown List	Yes	REL_TYPE	What is the customer type? Select "Mixed" if it is unclear if the customers are residential or commercial.	
Has this feeder been identified on the worst performing feeder report in the past 2 years, OR has this area been identified by the Key Accounts Manager as an area of concern?	Dropdown List	Yes	REL_WORS	Has this feeder been identified on the worst performing feeder report in the past 2 years, OR has this area been identified by the Key Accounts Manager as an area of concern?	
(Optional Information Used in Legacy Projects and Not used in Value	Text	No	REL_NCUS		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Calculation) What is the average number of customers impacted by each failure?					
Provide the rationale or assumptions for the answers provided above.	Text	Yes	REL_TEXT		

Table 36: Reliability Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
What is the customer type?	• Commercial [redacted] • Industrial [redacted] • Mixed Residential/Commercial [redacted] • Mixed Residential/Commercial/Industrial [redacted] • Mixed Residential/Industrial [redacted] • Purely Commercial/Industrial [redacted] • Residential [redacted]
Has this feeder been identified on the worst performing feeder report in the past 2 years, OR has this area been identified by the Key Accounts Manager as an area of concern?	• No [redacted] • Yes [redacted]

Table 37: Reliability Benefit Questionnaires Dropdown List Details

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]

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[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.9.2 Value Model Outputs

The **Reliability Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Reliability Benefit	Optional	• Reliability Benefit

Table 39: Reliability Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

5.2.1.10 Reliability for Spares Benefit

Reliability for Spares Benefit is used to assess the impact of spare equipment on reliability.

5.2.1.10.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields

Reliability for Spares Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Reliability for Spares Benefit Value Model.

Reliability for Spares Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the probability that a spare will be required in this year? (%)	Number (2 decimal places)	Yes	RS_PROB	Enter 15% as 15.	
Without a spare available what would be the expected outage duration? (days)	Number (2 decimal places)	Yes	RS_DUR	Without a spare available what would be the expected outage duration? (days)	
With a spare available what would be the expected outage duration? (days)	Number (2 decimal places)	Yes	RS_DURS	With a spare available what would be the expected outage duration? (days)	
If this spare is for redundant equipment: If no spare was available, and the equipment failed, what is the duration	Number (2 decimal places)	Yes	RS_DURR	If this spare is for redundant equipment: If no spare was available, and the equipment failed, what is the duration	

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
for which redundancy will be lost (system will be under single contingency)? (days)				for which redundancy will be lost (system will be under single contingency)? (days)	
What is the peak load (Connected KVA) served by this equipment?	Number (2 decimal places)	Yes	RS_PEAK	What is the peak load (Connected KVA) served by this equipment?	
(Optional Information Used in Legacy Projects and Not used in Value Calculation) What is the average number of customers impacted by each failure?	Number (2 decimal places)	No	RS_CUST		
Provide the rationale or assumptions for the answers provided above.	Text	Yes	RSText		

Table 40: Reliability for Spares Benefit - Outcome Time Varying Questionnaire

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

5.2.1.10.2 Value Model Outputs

The **Reliability for Spares Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Reliability for Spares Benefit	Optional	• Reliability for Spares Benefit

Table 42: Reliability for Spares Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

5.2.1.11 Technological Innovation Benefit

Technological Innovation Benefit is used to indicate that a new technology is adopted by Alectra. This Value Measure is used only when clearly new technology is adopted by Alectra; it does not apply when an upgrade to an existing technology is implemented. Technological Innovation Benefits are computed directly in Value Units so the conversion factor for the value measure is 1.

5.2.1.11.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

Technological Innovation Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Technological Innovation Benefit Value Model.

Technological Innovation Benefit - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Does this project introduce or apply new technology?	CheckBox	Yes	TechInno_TI1	Does this project introduce or apply new technology that has never been used at Alectra before (does not include enhancements to existing technology)?	
Provide the rationale or assumptions for the answers provided above.	Text	Yes	TechInno_Text		

Table 43: Technological Innovation Benefit - Outcome Time Varying Questionnaire

5.2.1.11.2 Value Model Outputs

The **Technological Innovation Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Technological Innovation Benefit	Optional	• Technological Innovation Benefit

Table 44: Technological Innovation Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.2.2 Costs

5.2.2.1 Future Revenue

Future Revenue is used to represent the value derived from expected cash flows (reimbursements) provided by the regulator.

For Buckets (programmatic work), the **Future Revenue Model** uses economic principles to determine what the necessary cash flows are for the 25 years following the In-Service Date of the project to entirely offset the **Investment Cost**. A Service Measure called **Future Revenue Total** provides the exact cash flows amounts in dollars while the **Future Revenue** value measure yields the value in value units.

For Projects, users define the **expected revenue** for the first 5 years as well as the expected steady-state revenue from year 6 to year 25.

5.2.2.1.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields
- System Core Fields

Future Revenue User Questionnaires

The user is prompted to answer the following Questionnaires for the Future Revenue Value Model.

Project - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Year One Future Revenue	Number (2 decimal places)	No	YearOneRevenue	Enter the expected future revenue for the first year of customer connections.	
Year Two Future Revenue	Number (2 decimal places)	No	YearTwoRevenue	Enter the expected future revenue for the second year of customer connections.	
Year Three Future Revenue	Number (2 decimal places)	No	YearThreeRevenue	Enter the expected future revenue for the third year of customer connections.	
Year Four Future Revenue	Number (2 decimal places)	No	YearFourRevenue	Enter the expected future revenue for the fourth year of customer connections.	
Year Five Future Revenue	Number (2 decimal places)	No	YearFiveRevenue	Enter the expected future revenue for the fifth year of customer connections.	
Steady State Future Revenue	Number (2 decimal places)	No	YearSixSteadyStateRevenue	Enter the expected steady-state future revenue for the sixth year of customer connections and beyond.	
Provide a rationale or assumptions for	Text	Yes	`RationaleTimeInvariant`		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
the numbers provided.					

Table 45: Future Revenue - Outcome Time Varying Questionnaire

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Future Revenue Core Fields

- InvestmentSpendByAccountType

5.2.2.1.2 Value Model Outputs

The **Future Revenue** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Future Revenue	Optional	• Future Revenue • Future Revenue Total

Table 47: Future Revenue Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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    - [redacted]
    - [redacted]
    - [redacted]
- [redacted]

5.2.3 IT

5.2.3.1 Cyber Security Benefit

CyberSecurityBenefit measures the positive impact of a Project on Alectra's cyber security.

5.2.3.1.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

Cyber Security Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Cyber Security Benefit Value Model.

Cyber Security Benefit - Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Will the implementation of this project provide enhanced security features or functionality?	Dropdown List	Yes	EnhancedSecurity		
Is this project impacting a business critical system?	Dropdown List	Yes	ImpactingBCS	e.g., GIS, OMS, SCADA, ERP, CIS, Microsoft O365, Citrix VDI	
Will this project replace a system that is end-of-life or end-of-support?	Dropdown List	Yes	SystemEOL	End-of-life: Companies often label products as EOL several years after production has ended. When a device reaches EOL status, the company ends official support, no longer providing technical help or hardware repairs. End-of-Support: Refers to a situation in which a company ceases support for a product or service. This is typically applied to hardware and software products when a company releases a new version and ends support for previous versions.	
What is the likelihood of achieving this benefit?	Number (1 decimal place)	Yes	CyberSecurityLikelihood		
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 48: Cyber Security Benefit - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
Will the implementation of this project provide enhanced security features or functionality?	• No [redacted] • Yes [redacted]
Is this project impacting a business critical system?	• No [redacted] • Yes [redacted]
Will this project replace a system that is end-of-life or end-of-support?	• End-of-life [redacted] • End-of-support [redacted] • Neither [redacted]

Table 49: Cyber Security Benefit Questionnaires Dropdown List Details

5.2.3.1.2 Value Model Outputs

The **Cyber Security Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Cyber Security Benefit	Optional	• Cyber Security Benefit

Table 50: Cyber Security Benefit Output Value Measures

[redacted]

[redacted]

5.2.3.2 Cyber Security Complex

Cyber Security Complex measures the mitigation of the risk of cyber-security breaches. The value model is intended to capture the multi-dimensional nature of most cybersecurity projects by outputting multiple relevant Value Measures.

5.2.3.2.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Cyber Security Complex User Questionnaires

The user is prompted to answer the following Questionnaires for the Cyber Security Complex Value Model.

Cyber Security Risk - Baseline - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the probability of a cyber security threat?	Dropdown List	Yes	CyberSecurityProbability		
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 51: Cyber Security Complex - Baseline Time Varying Questionnaire

LEGACY - Cyber Security Risk - Baseline - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Will this investment have a direct positive impact on Cyber Security?	Dropdown List	Yes	ImpactCyberSecurity		
Is this investment impacting any business critical systems?	Dropdown List	Yes	ImpactExternalCyberSecurity	E.g. OMS, GIS, SCADA, CRS, ERP, Microsoft O365, Citrix VDI	
Does this investment have a direct impact on assets governed	Dropdown List	Yes	ImpactComplianceCyberSecurity		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
by any Alectra policy/standard or any industry compliance or governing body (i.e. Regulatory or NERC)?					
What is the probability of a cyber security threat?	Dropdown List	Yes	CyberSecurityProbability		
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 52: Cyber Security Complex - Baseline Time Varying Questionnaire

Cyber Security Risk - Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
What is the probability of a cyber security threat?	Dropdown List	Yes	CyberSecurityProbability		
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 53: Cyber Security Complex - Outcome Time Varying Questionnaire

LEGACY - Cyber Security Risk - Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Will this investment have a direct positive impact on Cyber Security?	Dropdown List	Yes	ImpactCyberSecurity		
Is this investment impacting any business critical systems?	Dropdown List	Yes	ImpactExternalCyberSecurity	E.g. OMS, GIS, SCADA, CRS, ERP, Microsoft O365, Citrix VDI	
Does this investment have a direct impact on assets governed	Dropdown List	Yes	ImpactComplianceCyberSecurity		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
by any Alectra policy/standard or any industry compliance or governing body (i.e. Regulatory or NERC)?					
What is the probability of a cyber security threat?	Dropdown List	Yes	CyberSecurityProbability		
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 54: Cyber Security Complex - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
What is the probability of a cyber security threat?	• A - Very High Probability due to known threat or immediate action required [redacted] • B - High Probability, recommended action req. from manufacturer, vendor/auth. 3rd party [redacted] • C - Medium Probability due to routine or scheduled action [redacted] • D - Low Probability due to minimal threat or existing mechanism(s) in place are sufficient [redacted] • E - Zero or Minimal Probability [redacted]
Does this investment have a direct impact on assets governed by any Alectra policy/standard or any industry compliance or governing body (i.e. Regulatory or NERC)?	• No [redacted] • Yes [redacted]
Will this investment have a direct positive impact on Cyber Security?	• Direct [redacted] • Indirect [redacted] • No [redacted]
Is this investment impacting any business critical systems?	• No [redacted] • Yes [redacted]

Table 55: Cyber Security Complex Questionnaires Dropdown List Details

Cyber Security Complex Core Fields

- CurrentMeasureBaselineUnits

- CurrentMeasureBaselineZynos
- InvestmentSpendByAccountType

5.2.3.2.2 Value Model Outputs

The **Cyber Security Complex** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Cyber Security Complex	Optional	• Cyber Security Risk

Table 56: Cyber Security Complex Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.2.3.3 Data Reuse Benefit

The **Data Reuse Benefit** Value Model measures the benefit of Collection, Sharing and Reuse enhancements to an organizations' data landscape.

5.2.3.3.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields
- System Core Fields

Data Reuse Benefit User Questionnaires

The user is prompted to answer the following Questionnaires for the Data Reuse Benefit Value Model.

Data Reuse Benefit - Outcome - Time Invariant

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Will the data derived from this project be included in the Alectra Enterprise Data Warehouse for sharing and reuse across the organization?	Dropdown List	Yes	ContributionDataSharingReuse		
Will this investment increase the speed or frequency with which a dataset is available?	Dropdown List	Yes	SpeedFrequencyDataAccess		
What is the number of potential users who are expected to use this data?	Dropdown List	Yes	NumberUsersDataUse		
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 57: Data Reuse Benefit - Outcome Time Invariant Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
Will the data derived from this project be included in the Alectra Enterprise Data Warehouse for sharing and reuse across the organization?	• No [redacted] • Yes [redacted]
What is the number of potential users who are expected to use this data?	• 1. >1000 [redacted] • 2. 100-1000 [redacted] • 3. 10-100 [redacted] • 4. <10 [redacted]
Will this investment increase the speed or frequency with which a dataset is available?	• 1. Significantly [redacted] • 2. Moderately [redacted] • 3. Minimally [redacted]

Measure Prompt	Dropdown (Value)
	• 4. No [redacted]

Table 58: Data Reuse Benefit Questionnaires Dropdown List Details

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]

[redacted]

Data Reuse Benefit Core Fields

- InvestmentSpendByAccountType

5.2.3.3.2 Value Model Outputs

The **Data Reuse Benefit** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Data Reuse Benefit	Optional	• Data Collection, Sharing and Reuse

Table 60: Data Reuse Benefit Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

[redacted]

5.2.3.4 IT Capacity Risk

IT Capacity Risk represents the potential productivity impact of failing to meet Alectra's IT requirements. An example of IT capacity risk would be a network link between sites that potentially does not have the bandwidth required to support all of the users at one site.

5.2.3.4.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

IT Capacity Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the IT Capacity Risk Value Model.

IT Capacity Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Comment	Text	Yes	RiskTextComment		

Table 61: IT Capacity Risk - Baseline Time Varying Questionnaire

IT Capacity Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 62: IT Capacity Risk - Outcome Time Varying Questionnaire

IT Capacity Risk Core Fields

- InvestmentSpendByAccountType

5.2.3.4.2 Value Model Outputs

The **IT Capacity Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
IT Capacity Risk	Optional	• IT Capacity Risk

Table 63: IT Capacity Risk Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

- [redacted]
- [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

[redacted]

5.2.3.5 IT Technical Risk

IT Technical Risk captures the value generated by investments which mitigate the risk of software, application, or asset performance/operability shortfalls. This includes technical or compliance issues or systems becoming unsupported (e.g. expiring support agreements).

5.2.3.5.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields
- System Core Fields

IT Technical Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the IT Technical Risk Value Model.

IT Technical Risk - Baseline - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Will the current software or asset be out of support/warranty within the calendar year?	Dropdown List	Yes	ITWarrantyExpiryBaseline		
What would the level of vendor support,	Dropdown List	Yes	ITRiskVendorSupportBaseline		

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
response time and cost be if the current software or asset were out of support/warranty?					
What is the impact, or significant financial impact, on business if the current software/application or asset is non-operational?	Dropdown List	Yes	ITSeverityBusinessImpactBaseline		
What is the approximate impacted number of users/employees of the software/application ?	Dropdown List	Yes	ITSeverityNumUsersBaseline		
Is the current software or asset out of compliance OR facing imminent risk of being out of compliance?	Dropdown List	Yes	ITRiskComplianceBaseline	Either IT compliance or regulatory compliance	
How much downtime does the current software/application or asset experience?	Dropdown List	Yes	ITDurationDowntimeImpactBaseline		
Is the current software or asset business critical or does it support a business critical application?	Dropdown List	Yes	ITRiskBusinessCriticalBaseline	E.g. OMS, GIS, SCADA, CRS, ERP, Microsoft O365, Citrix VDI	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 64: IT Technical Risk - Baseline Time Varying Questionnaire

LEGACY - IT Technical Risk - Baseline - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Does the proposed solution result in the asset/software being easier or cheaper to maintain relative to the status quo?	Dropdown List	Yes	ITRiskEasierMaintain		
Will the newly implemented software or asset be out of support/warranty within the calendar year?	Dropdown List	Yes	ITWarrantyExpiry		
What would the level of vendor support, response time and cost be if the newly implemented software or asset were out of support/warranty?	Dropdown List	Yes	ITRiskVendorSupport		
What is the impact, or significant financial impact, on business if the newly implemented software/application or asset is non-operational?	Dropdown List	Yes	ITSeverityBusinessImpact		
What is the approximate impacted number of users/employees of the newly implemented software/application?	Dropdown List	Yes	ITSeverityNumUsers		
Is the newly implemented software or asset out of compliance OR facing imminent risk of being out of compliance?	Dropdown List	Yes	ITRiskCompliance	Either IT compliance or regulatory compliance	
How much downtime does the newly implemented software/application or asset experience?	Dropdown List	Yes	ITDurationDowntimeImpact		
Is the newly implemented software or asset business critical or does it support a business critical application?	Dropdown List	Yes	ITRiskBusinessCritical	E.g. OMS, GIS, SCADA, CRS, ERP, Microsoft O365, Citrix VDI	
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 65: IT Technical Risk - Baseline Time Varying Questionnaire

IT Technical Risk - Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Does the proposed solution result in the asset/software being easier or cheaper to maintain relative to the status quo?	Dropdown List	Yes	ITRiskEasierMaintain		
Will the newly implemented software or asset be out of support/warranty within the calendar year?	Dropdown List	Yes	ITWarrantyExpiry		
What would the level of vendor support, response time and cost be if the newly implemented software or asset were out of support/warranty?	Dropdown List	Yes	ITRiskVendorSupport		
What is the impact, or significant financial impact, on business if the newly implemented software/application or asset is non-operational?	Dropdown List	Yes	ITSeverityBusinessImpact		
What is the approximate impacted number of users/employees of the newly implemented software/application?	Dropdown List	Yes	ITSeverityNumUsers		
Is the newly implemented software or asset out of compliance OR facing imminent risk of being out of compliance?	Dropdown List	Yes	ITRiskCompliance	Either IT compliance or regulatory compliance	
How much downtime does the newly implemented software/application or asset experience?	Dropdown List	Yes	ITDurationDowntimeImpact		
Is the newly implemented software or asset business critical or does it support a business critical application?	Dropdown List	Yes	ITRiskBusinessCritical	E.g. OMS, GIS, SCADA, CRS, ERP, Microsoft O365, Citrix VDI	

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 66: IT Technical Risk - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
How much downtime does the current software/application or asset experience?	• A - Much more than average downtime (>2x) [redacted] • B - More than average downtime [redacted] • C - About average downtime [redacted] • D - Less than average downtime [redacted] • E - Much less than average downtime (<0.5x) [redacted] • F) Solution has no impact on downtime [redacted]
Is the current software or asset business critical or does it support a business critical application?	• No [redacted] • Yes [redacted]
Is the current software or asset out of compliance OR facing imminent risk of being out of compliance?	• No [redacted] • Yes [redacted]
What would the level of vendor support, response time and cost be if the current software or asset were out of support/warranty?	• A - No support from vendor and no upgrade available [redacted] • B - No support from vendor but upgrade available [redacted] • C - High cost (>$100k) and/or long response time (>2 weeks) [redacted] • D - Medium cost (>$50k) and/or long response time (>1 week) [redacted] • E - Low cost ($10-50k) and/or response time (<2 days) [redacted] • F - Insignificant cost and/or response time [redacted]
What is the impact, or significant financial impact, on business if the current software/application or asset is non-operational?	• A - High (50% decrease in productivity or a significant financial impact) [redacted] • B - Medium (25% decrease in productivity or a moderate financial impact) [redacted] • C - Low (10% decrease in productivity or a low financial impact) [redacted]

Measure Prompt	Dropdown (Value)
	• D - None [redacted]
What is the approximate impacted number of users/employees of the software/application?	• A - >500 users/employees [redacted] • B - 251-500 users/employees [redacted] • C - 151-250 users/employees [redacted] • D - 26-150 users/employees [redacted] • E - 0-25 users/employees [redacted]
Will the current software or asset be out of support/warranty within the calendar year?	• No [redacted] • Yes [redacted]
How much downtime does the newly implemented software/application or asset experience?	• A - Much more than average downtime (>2x) [redacted] • B - More than average downtime [redacted] • C - About average downtime [redacted] • D - Less than average downtime [redacted] • E - Much less than average downtime (<0.5x) [redacted] • F) Solution has no impact on downtime [redacted]
Is the newly implemented software or asset business critical or does it support a business critical application?	• No [redacted] • Yes [redacted]
Is the newly implemented software or asset out of compliance OR facing imminent risk of being out of compliance?	• No [redacted] • Yes [redacted]
Does the proposed solution result in the asset/software being easier or cheaper to maintain relative to the status quo?	• A - Easier or cheaper to maintain [redacted] • B - About average maintenance cost [redacted] • C - More difficult or more costly to maintain [redacted]
What would the level of vendor support, response time and cost be if the newly implemented software or asset were out of support/warranty?	• A - No support from vendor and no upgrade available [redacted] • B - No support from vendor but upgrade available [redacted] • C - High cost (>$100k) and/or long response time (>2 weeks) [redacted] • D - Medium cost (>$50k) and/or long response time (>1 week) [redacted] • E - Low cost ($10-50k) and/or response time (<2 days) [redacted] • F - Insignificant cost and/or response time [redacted]

Measure Prompt	Dropdown (Value)
What is the impact, or significant financial impact, on business if the newly implemented software/application or asset is non-operational?	• A - High (50% decrease in productivity or a significant financial impact) [redacted] • B - Medium (25% decrease in productivity or a moderate financial impact) [redacted] • C - Low (10% decrease in productivity or a low financial impact) [redacted] • D - None [redacted]
What is the approximate impacted number of users/employees of the newly implemented software/application?	• A - >500 users/employees [redacted] • B - 251-500 users/employees [redacted] • C - 151-250 users/employees [redacted] • D - 26-150 users/employees [redacted] • E - 0-25 users/employees [redacted]
Will the newly implemented software or asset be out of support/warranty within the calendar year?	• No [redacted] • Yes [redacted]

Table 67: IT Technical Risk Questionnaires Dropdown List Details

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

IT Technical Risk Core Fields

- CurrentMeasureBaselineUnits
- CurrentMeasureBaselineZynos
- InvestmentSpendByAccountType

5.2.3.5.2 Value Model Outputs

The **IT Technical Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
IT Technical Risk	Optional	• IT Technical Risk

Table 69: IT Technical Risk Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted] [redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	[redacted]
	[redacted]	
[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

5.2.4 Risks

5.2.4.1 Compliance Risk

Compliance Risk is used to capture the impact of an event or a failure which would cause the utility to fail to comply with a government or regulatory mandate or with an internal policy.

5.2.4.1.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Configurable Fields
- System Core Fields

Compliance Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Compliance Risk Value Model.

Compliance Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Compliance Classification	Dropdown List	Yes	ComplianceClassification		
Fine Frequency	Dropdown List	Yes	FineFrequency		
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 70: Compliance Risk - Baseline Time Varying Questionnaire

Compliance Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Compliance Classification	Dropdown List	Yes	ComplianceClassification		
Fine Frequency	Dropdown List	Yes	FineFrequencyOutcome		
Provide a rationale or assumptions for the numbers provided.	Text	Yes	RationaleTimeInvariant		

Table 71: Compliance Risk - Outcome Time Varying Questionnaire

Dropdown List Detail

Measure Prompt	Dropdown (Value)
Compliance Classification	• Connection and Cost Recovery Agreements [redacted] • Corporate or Other Contractual Issues [redacted] • Distribution System Code [redacted] • ESA Regulations [redacted] • IESO Requirements [redacted] • Measurement Canada [redacted] • Municipal By-laws [redacted] • Other [redacted] • Public Service Works on Highway Act (PSWHA) [redacted]
Fine Frequency	• A - Almost Certain [redacted] • B - Once In 2 Years [redacted] • C - Once In 5 Years [redacted] • D - Once In 10 Years [redacted] • E - Once In 20 Years [redacted] • F - None [redacted]

Table 72: Compliance Risk Questionnaires Dropdown List Details

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]

[redacted]

Compliance Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.1.2 Value Model Outputs

The **Compliance Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Compliance Risk	Optional	• Compliance Risk

Table 74: Compliance Risk Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.2.4.2 Distribution System Capacity Risk

Distribution System Capacity Risk is used when a failure or event will threaten Alectra's ability to deliver power to all customers according to tariff.

5.2.4.2.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Distribution System Capacity Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Distribution System Capacity Risk Value Model.

Distribution System Capacity Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Comment	Text	Yes	RiskTextComment		

Table 75: Distribution System Capacity Risk - Baseline Time Varying Questionnaire

Distribution System Capacity Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 76: Distribution System Capacity Risk - Outcome Time Varying Questionnaire

Distribution System Capacity Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.2.2 Value Model Outputs

The **Distribution System Capacity Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Distribution System Capacity Risk	Optional	• Distribution System Capacity Risk

Table 77: Distribution System Capacity Risk Output Value Measures

[redacted]

[redacted]

5.2.4.3 Environmental Risk

Environmental Risk is assessed based on the cost of remediation efforts to reverse any damage potentially caused. Damage so severe as not to be reversible is ranked using the most severe consequence classification.

5.2.4.3.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Environmental Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Environmental Risk Value Model.

Environmental Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 78: Environmental Risk - Baseline Time Varying Questionnaire

Environmental Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 79: Environmental Risk - Outcome Time Varying Questionnaire

Environmental Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.3.2 Value Model Outputs

The **Environmental Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Environmental Risk	Optional	• Environmental Risk

Table 80: Environmental Risk Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.2.4.4 Financial Risk

Financial Risk is used to represent a failure mode or an event that will have a direct financial consequence for Alectra. For example, if the failure of a piece of equipment in a switchyard causes the destruction of a nearby breaker, there would be a financial risk associated with that failure whose consequence is valued at the cost of repair or replacement of the breaker.

Assessment of financial risk is based on the direct cost to Alectra of a failure or event occurring.

5.2.4.4.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Financial Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Financial Risk Value Model.

Financial Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 81: Financial Risk - Baseline Time Varying Questionnaire

Financial Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 82: Financial Risk - Outcome Time Varying Questionnaire

Financial Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.4.2 Value Model Outputs

The **Financial Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Financial Risk	Optional	• Financial Risk

Table 83: Financial Risk Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]

[redacted]

5.2.4.5 PA Results

The PA Results Value Model allows users to associate results from Predictive Analytics strategy alternatives with Projects in Copperleaf Portfolio. There are four value measures that are used: Financial Risk, Safety Risk, Environmental Risk, and Reliability Risk. There are no calculations as the value units that are input for a given year for a value measure is what is output by the PA Results model (along with the application of inflation and discount rates accordingly).

5.2.4.5.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires

PA Results User Questionnaires

The user is prompted to answer the following Questionnaires for the PA Results Value Model.

Poles - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Poles Safety Risk	Number (4 decimal places)	No	PolesSafetyRisk		
Poles Reliability Risk	Number (4 decimal places)	No	PolesReliabilityRisk		
Poles Environmental Risk	Number (4 decimal places)	No	PolesEnvironmentalRisk		
Poles Financial Risk	Number (4 decimal places)	No	PolesFinancialRisk		

Table 84: PA Results - Outcome Time Varying Questionnaire

Switches - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Switches Safety Risk	Number (4 decimal places)	No	SwitchesSafetyRisk		
Switches Reliability Risk	Number (4 decimal places)	No	SwitchesReliabilityRisk		
Switches Environmental Risk	Number (4 decimal places)	No	SwitchesEnvironmentalRisk		
Switches Financial Risk	Number (4 decimal places)	No	SwitchesFinancialRisk		

Table 85: PA Results - Outcome Time Varying Questionnaire

Switchgear - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Switchgear Safety Risk	Number (4 decimal places)	No	SwitchgearSafetyRisk		
Switchgear Reliability Risk	Number (4 decimal places)	No	SwitchgearReliabilityRisk		
Switchgear Environmental Risk	Number (4 decimal places)	No	SwitchgearEnvironmentalRisk		
Switchgear Financial Risk	Number (4 decimal places)	No	SwitchgearFinancialRisk		

Table 86: PA Results - Outcome Time Varying Questionnaire

Transformers - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Transformers Safety Risk	Number (4 decimal places)	No	TransformersSafetyRisk		
Transformers Reliability Risk	Number (4 decimal places)	No	TransformersReliabilityRisk		
Transformers Environmental Risk	Number (4 decimal places)	No	TransformersEnvironmentalRisk		
Transformers Financial Risk	Number (4 decimal places)	No	TransformersFinancialRisk		

Table 87: PA Results - Outcome Time Varying Questionnaire

Cables - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Cables Safety Risk	Number (4 decimal places)	No	CablesSafetyRisk		
Cables Reliability Risk	Number (4 decimal places)	No	CablesReliabilityRisk		
Cables Environmental Risk	Number (4 decimal places)	No	CablesEnvironmentalRisk		
Cables Financial Risk	Number (4 decimal places)	No	CablesFinancialRisk		

Table 88: PA Results - Outcome Time Varying Questionnaire

Fleet - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Fleet Safety Risk	Number (4 decimal places)	No	FleetSafetyRisk		
Fleet Reliability Risk	Number (4 decimal places)	No	FleetReliabilityRisk		
Fleet Environmental Risk	Number (4 decimal places)	No	FleetEnvironmentalRisk		
Fleet Financial Risk	Number (4 decimal places)	No	FleetFinancialRisk		

Table 89: PA Results - Outcome Time Varying Questionnaire

5.2.4.5.2 Value Model Outputs

The **PA Results** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
PA Results	Optional	• Financial Risk • Safety Risk • Reliability Risk • Environmental Risk

Table 90: PA Results Output Value Measures

5.2.4.6 Reputational Risk

Reputational Risk represents the risk that a failure or event will cause Alectra customers or other external stakeholders to lose or weaken confidence in the organization.

5.2.4.6.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Reputational Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Reputational Risk Value Model.

Reputational Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 91: Reputational Risk - Baseline Time Varying Questionnaire

Reputational Risk Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 92: Reputational Risk - Outcome Time Varying Questionnaire

Reputational Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.6.2 Value Model Outputs

The **Reputational Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Reputational Risk	Optional	• Reputational Risk

Table 93: Reputational Risk Output Value Measures

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]

[redacted]

5.2.4.7 Safety Risk

Alectra does not purposefully expose employees or the general public to known safety hazards.

If a significant safety risk that could lead to serious injury or death has been identified then that risk must be mitigated either by a capital investment, an O&M investment or some kind of operating restriction. If no operating restriction is possible to mitigate the risk and the only way to address the safety risk is by a capital investment, then that investment should be considered mandatory. Multiple alternatives may be created to represent multiple approaches to mitigating the risk on a temporary or permanent basis.

5.2.4.7.1 Value Model Inputs

Takes Inputs from:

- User Questionnaires
- System Core Fields

Safety Risk User Questionnaires

The user is prompted to answer the following Questionnaires for the Safety Risk Value Model.

Safety Risk - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 94: Safety Risk - Baseline Time Varying Questionnaire

Safety Override Outcome - Time Varying

Measure Prompt	Type	Required	Measure Prompt Code	Description	Unit
Risk Probability	Dropdown List	Yes	RiskProbability	The probability of the risk.	
Risk Consequence	Dropdown List	Yes	RiskConsequence	The consequence of a risk.	
Risk Comment	Text	Yes	RiskTextComment		

Table 95: Safety Risk - Outcome Time Varying Questionnaire

Safety Risk Core Fields

- InvestmentSpendByAccountType

5.2.4.7.2 Value Model Outputs

The **Safety Risk** Value Model outputs the Value Measures as shown below:

Value Model	Usage	Output Value Measures
Safety Risk	Optional	• Safety Risk

Table 96: Safety Risk Output Value Measures

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]

[redacted]

[redacted]

6 Contact Copperleaf

Copperleaf provides decision analytics to organizations facing the challenges of managing critical infrastructure. Our enterprise software solutions leverage operational, financial and asset data to empower our clients to make investment decisions that deliver the highest business value. Copperleaf is a member of The Institute of Asset Management (IAM) and actively participates in shaping the future of asset management standards, including ISO 55000. Headquartered in Vancouver, our solutions are distributed and supported by regional staff and partners worldwide. We are committed to building a better world, one decision at a time.

Appendix D

Copperleaf Value Framework Assurance Review

AMCL+
LEADING ASSET MANAGEMENT

ALECTRA UTILITIES

Copperleaf Value Framework Review

Summary of Findings

Date: 29th September 2025

iAM endorsed ASSESSOR

iAM endorsed TRAINER

The Institute of Asset Management iAM PATRON

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29th September 2025	Sarah Vine	Richard Edwards	Malcolm Christie

EXECUTIVE SUMMARY

AMCL is a globally recognized leader in asset management professional services, renowned for its expertise in asset management strategy, digital transformation, and operational excellence. Since its founding in 1997, AMCL has established a reputation for shaping asset management best practices and delivering tangible value to infrastructure owners and operators. With over 200 specialists across offices in the United States, Canada, the United Kingdom, the Middle East, East Asia, and Australia, AMCL provides deep sector knowledge and a hands-on approach to improving asset performance.

Alectra Utilities uses decision-support software licenced by Copperleaf Technologies Inc. to support the development of Alectra Utilities' 5-year capital plan.

AMCL were engaged to:

(1) review and confirm or provide recommendations with respect to, Alectra Utilities'

(a) Copperleaf (C55) Value Framework and

(b) business case optimization process, and

(2) assess whether Alectra Utilities' Copperleaf Value Framework is consistent with asset management best practices.

The scope of the assessment was limited to the business case optimization process from the stage at which an investment need is identified to the stage when the Capital Investment Plan is finalized. We reviewed the activities that would influence the outcome of the value-based decision-making approach; however, we did not review any upstream technical, engineering or system planning processes, and did not extend into downstream delivery processes.

Given the above context, the scope of this review focussed on:

- Alectra Utilities' development of the value framework.
- Evaluation of project options against the value framework.
- Alectra Utilities' development and application of the constraints and objectives applied to the portfolio optimization within the Copperleaf software.
- The financial controls and change management controls relating to the optimized portfolio.

Interviews with members of the Asset Management Team were held over a period of three weeks, information provided was accepted at face value with no audit trailing.

Summary of Findings

The Value Framework

Alectra Utilities has incorporated the four Outcomes defined by the Ontario Energy Board (OEB) in the Renewed Regulatory Framework (RRF)[1] for electricity into eight Value Drivers. These Value Drivers have been further disaggregated into 23 Value Measures which are quantified within Value Models to evaluate asset interventions. Collectively, the Value Drivers, Value Measures, and Value Models form a comprehensive Value Framework.

We conclude Alectra Utilities has developed a Value Framework that demonstrates clear alignment between the OEB's four Outcomes and its asset decision-making, and that this is both appropriate and consistent with good public utility practice.

Application of the Value Framework

AMCL reviewed Alectra Utilities' business processes related to decision-making, focusing on governance and controls for business case development and approval. Alectra Utilities has implemented measures to safeguard the integrity of its planning approach and ensure consistent application of the Value Framework.

Prior to each planning cycle, Alectra Utilities provides mandatory training to all staff involved in the investment planning process. This training ensures a shared understanding of governance, responsibilities, and accountabilities, and includes specific instruction for approvers and authorizers on the use of the software and what they are responsible for checking prior to approval.

Review and approval processes are largely automated within Copperleaf software, with embedded workflows and governance ensuring compliance. Overall, the evaluation of investments and options against the Value Framework is well controlled and being consistently applied by contributors across the business.

Plan Confidence

The data and information required to support robust, justifiable, and transparent asset decision-making are included in Alectra Utilities' data improvement plans. Senior-level roles exist with accountability for the management, use, and access to the Copperleaf portfolio optimization software. Access is provided to the appropriate resources, and training supports consistent application across the organization.

Based on the information provided[2], we conclude that the outputs from Copperleaf are derived from the best available information, subject to adequate governance, and follow a logical, methodical, and justifiable process.

Summary

Alectra Utilities uses decision-support software licensed from Copperleaf Technologies Inc. to support the development of its capital investment portfolio.

Based on the information provided[2], we are of the opinion that the Value Framework, as configured within Copperleaf, can be trusted to inform business decision-making in a manner consistent with both the OEB Outcomes and Alectra Utilities' corporate objectives and performance targets.

[1] Report of the Board - A Renewed Regulatory Framework for Electricity Distributors: A Performance Based Approach
[2] *Information provided to AMCL was taken at face value with no audit trailing.*

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1. INTRODUCTION

1.1 CORPORATE STRUCTURE

Established in the United Kingdom in 1946, Turner & Townsend is an independent professional services company specializing in portfolio management, program management, project management, cost management, asset management and advisory consulting across the natural resources, infrastructure, and real estate sectors.

Turner & Townsend operates across seven global regions, with over 6,800 staff working in 112 offices in 46 countries. Turner & Townsend has supported clients in the U.S. and Canada since 1995.

Turner & Townsend operates as an independently owned and operated Limited Liability Partnership (LLP). In Canada, the corporate legal entity is Turner & Townsend Canada Inc., headquartered at 2 St. Clair Avenue West, Floor 12, Toronto, Ontario, M4V 1L5.

Following a successful Joint Venture in the United States, AMCL joined the Turner & Townsend Group of companies as a subsidiary to create an end-to-end advisory service for infrastructure owners and investors worldwide. As a subsidiary, AMCL enhances Turner & Townsend's capability to provide an end-to-end advisory service for infrastructure owners and investors worldwide, integrating best-in-class asset management with broader capital program and operational efficiency expertise.

Our corporate structure is shown in Figure 1 below.

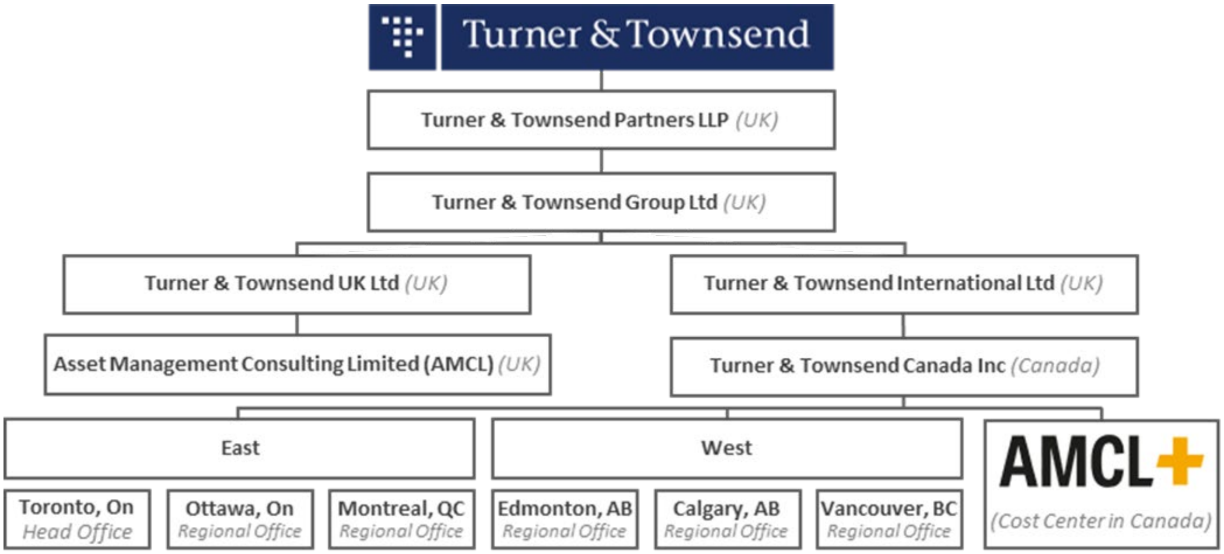

Figure 1 Corporate Structure

1.2 ABOUT AMCL

Founded in the United Kingdom in 1997, AMCL is recognized as the world's leading specialist infrastructure, asset management and asset information consultancy. With over 200 Asset Management specialists and offices in the United States, Canada, the United Kingdom, the Middle East, East Asia and Australia we have one of the largest teams of specialist infrastructure asset management consultants in the world. AMCL is at the forefront of the thinking and practice of asset management and was a key participant in preparing the original 2004 version of British Standards Institute (BSI) PAS 55, it's 2008 revision, and the development of ISO 55000.

With a global reputation for leadership in asset management thinking and on-the-ground delivery, we have assisted over 300 infrastructure organizations across the defence, energy, transportation, and utility sectors. Our teams thrive on the opportunities to share learning and good practice with our clients enabling them to realize true value from the work we deliver.

AMCL has been providing Asset Management services to clients in North America since 2012, including many power companies and has been supporting the Canadian power sector with Asset Management training and consultancy services since 2018, including providing high-value technical guidance and support across power generation, transmission and distribution. These include BC Hydro, Columbia Power, ENMAX, SaskPower, Manitoba Hydro, Toronto Hydro and Newfoundland Power.

AMCL personnel serve on a range of Asset Management committees within the IAM and power industry organizations such as the Center for Energy Advancement through Technological Innovation (CEATI).

AMCL globally has also delivered guidance on investment planning and undertaken a portfolio optimization software comparison study, all of which are available here https://www.amcl.com/news/

1.3 ASSESSMENT TEAM

Sarah Vine is the Director of Asset Management for AMCL Canada. For over 30 years Sarah has been involved with various facets of asset management, including developing industry sector specific asset management maturity models, and regulatory assessment models and has been an Institute of Asset Management (IAM) Endorsed Maturity Assessor for over 15 years.

Sarah has held long term roles (6+ years) as a Technical Assessor of long-term business plans for rate applications, leading teams undertaking assurance of capital and operating cost forecasts and audit of data and performance metrics on behalf of regulators in the UK and UAE. This included presenting findings and preparing and signing off the formal "Statement of Reasonableness" of asset strategies, investment plans and fuel forecasts for power generation, transmission and distribution along with the projected impact on levels of service and cost of service.

Sarah is a Fellow of the IAM, the current Chair of IAM Canada Board and a member of the IAM's global Knowledge Leadership Group.

2. ASSET MANAGEMENT

2.1 VALUE BASED DECISION-MAKING

ISO 55000 is a series of Asset Management standards comprised of 55000 (overview, terminology), 55001 (requirements) and 55002 (guidelines). In ISO 55000:2024 Asset Management is defined in section 3.2.1 as *"coordinated activities of an organization to realize value from assets"* [3] and ISO 55001: 2024 states: *"The primary outcomes of asset management are the realization of value and the achievement of organizational objectives."* [4]

ISO 55001: 2024 was released in 2024, replacing ISO 55001:2014. This update brings ISO 55001 in line with the latest accepted good Asset Management practices and introduces specific requirements to ensure asset management decision-making is value driven.

Industry experts and representatives from asset intensive organizations from around the world were consulted during the development of the new standard, fully endorsing the mandatory requirement for a decision-making framework, which includes developing and actively applying a Value Framework; the specific requirements are laid out in ISO 55001: 2024 Clause 4.5 Asset management decision-making.

The Institute of Asset Management provides further guidance on asset management decision-making in its Subject Specific Guidance for Capital Investment, Operations and Maintenance Decision Making [5] specifically:

> ***4.1.2. Decision Making Maturity***
> *"The criteria for decision making should be documented to the necessary level of detail to ensure consistency and alignment. The criteria will seek to maximise 'value' within constraints such as compliance, stakeholder requirements, agreed objectives and strategies."*

And

> ***5.3.2 Quantifying Value***
> *"A well-defined value framework will enable a value-based decision-making approach that aligns with the organisational strategic objectives of the organisation to consistently quantify investment value across the business."*

[3] (International Organization for Standardization 2024)
[4] (International Organization for Standardization 2024)
[5] (The Institute of Asset Management 2016)

2.2 BEST PRACTICES IN ASSET MANAGEMENT

There is no industry accepted definition of "Best Practices" in asset decision-making. As organizations vary in size, complexity and regulatory environment, an appropriate approach to decision making needs to reflect each organizations' specific purpose and context.

In summary, corporate and regulatory objectives and performance targets should be defined and organized into a structured and logical decision-making framework, or Value Framework, and these should inform the capital portfolio optimization criteria.

The Value Framework needs to include quantifiable Measures of Value so that individual asset interventions can be consistently evaluated based on their relative contribution to achieving the corporate level objectives and performance targets.

For the purposes of this assessment, we used the industry accepted definition of 'Competence' in Asset Management, using the scale defined by the IAM in its Maturity Guidance. In the Maturity Guidance, Competent is defined as *"The Organisation can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001"*[6]; this is a widely accepted definition of good practice in Asset Management around the world.

Regardless of whether an organization is ISO 55000 certified, the application of good practices in asset management is recommended for any publicly funded, infrastructure intensive, organization.

[6] (The Institute of Asset Management 2022)

2.3 ASSESSING PRACTICES IN INVESTMENT PLANNING

Asset Investment Planning is a fundamental business activity for infrastructure organizations worldwide. Organizations employ various approaches to investment planning, and no approach is the same, however, there are some common characteristics which are indicative of a more mature approach.

AMCL has developed an Asset Investment Planning diagnostic methodology that provides a reliable and consistent framework for rapidly assessing an organization's level of maturity in its asset investment planning approach across eight key organizational dimensions.

The assessment model takes a holistic approach and evaluates how well an organization can evidence what it does and how it does it. Importantly, the diagnostic assesses the level of maturity of the wider business capabilities such as investment planning business processes, organization design, data, technology and tooling and governance, not just the decision-making approach or its results.

The diagnostic methodology has been developed and refined through the many years of collective experience of seasoned asset management practitioners and investment planning specialists. In addition, the question set components and maturity scale used has been calibrated over many years and has benefitted from the outcome of over 200 separate maturity assessments which AMCL has performed on organisations across the globe from a wide variety of industry sectors including power and utilities, aviation, manufacturing, rail, highways and other critical infrastructure organisations from both the public and private sectors.

Whilst AMCL has not undertaken a formal diagnostic on Alectra Utilities' asset investment planning capabilities, we have followed the same assessment structure, following the eight criteria in Figure 4 below and used the definition of 'competent' as defined by the IAM and discussed in Section 2.2.

Figure 2 AMCL Asset Investment Planning Assessment Model

3. METHODOLOGY

3.1 BACKGROUND

Effective Asset Management involves understanding risks and uncertainties, forecasting demand and growth, and modelling interventions based on their impact on asset health and service levels. Maximizing value involves identifying the optimal timing and type of interventions to manage levels of service considering financial and operational constraints across the asset portfolio.

The evolving energy investment landscape, characterized by numerous variables and uncertain time horizons, significantly raises the complexity of asset decision-making for utilities. Advanced analytical methods are needed to optimize investments and effectively support decision-making.

Using decision-support software, organizations can undertake complex scenario-based investment decision-making with multiple constraints. Specific advantages of this approach include:

- Time phasing of investments to maximize benefit within cashflow constraints.
- Multiple intervention options can be considered for each investment need.
- Built-in workflows and approvals to ensure governance.
- Integration with other systems such as finance and project delivery.

Alectra Utilities uses decision-support software licenced by Copperleaf Technologies Inc. to support the development of their capital investment portfolio; for the remainder of this report, we will refer to the software as “Copperleaf”. Copperleaf incorporates three complimentary analytical methods to generate an optimized investment portfolio:

- **Multi-Criteria Analysis** (MCA) involves evaluating individual investments against multiple, often competing, criteria that are aligned to the organization’s values. These criteria usually include financial, environmental, safety, and performance factors. This approach allows for a more holistic assessment of investment options and is widely accepted as the foundation for value-based decision-making.
- **Constraint Analysis** is used to determine the boundaries or limitations within which all feasible investment portfolios must exist. These constraints can arise from various sources; typical constraints used in electrical distribution systems include resource constraints, project interdependencies, reliability targets and regulatory, legal or environmental commitments.
  Some criteria may be maximised and others minimised, as Alectra Utilities is optimizing its investment portfolio for maximum value, the theoretical ideal investment portfolio would return the maximum achievable benefit per dollar within the given constraints.
- **Portfolio Selection and Evaluation** having defined the constraints, there will be a finite set of feasible investment portfolio alternatives. The optimal portfolio is the one that delivers the best total value for money, within the constraints. Depending on the complexity of the constraints and the number of potential projects being evaluated, finding the optimal portfolio can involve evaluating many thousands of portfolio alternatives, so the Copperleaf decision-support software is needed to expedite the process.

One of the biggest challenges with software-based optimization is ensuring the transparency and justification of the outcome from the process; it is not practical to replicate the analysis manually outside the system. The business processes and governance upstream of the decision-making activity need to be well-defined, prescriptive, and subject to sufficient governance throughout the asset planning process before candidate projects are forwarded for optimization. Assurance of the output is therefore best achieved by reviewing how the system has been configured, and then reviewing the processes, assumptions, governance and controls that would have an impact on the selected portfolio of projects.

3.2 SCOPE AND STRUCTURE OF THE ASSESSMENT

To review the application of Alectra Utilities' value framework, Alectra Utilities provided information to AMCL on what it is using Copperleaf for, how it has been configured and how it is incorporated into Alectra Utilities' business planning activities. The outcome of this meeting was used to determine the basis for the assessment.

Copperleaf is being used to support the development of Alectra Utilities' 5-year capital plan. The scope of the assessment was limited to the business case optimization process outlined in Figure 5 below; from the stage at which individual investment options are identified to the stage when the capital investment plan is finalized. We did not review any upstream technical, engineering or system planning processes, and did not extend into downstream delivery processes. Specifically, the review focussed on the following four areas, corresponding to the numbered items identified in Figure 5 below:

1. Alectra Utilities' development of the Value Framework and Value Measures.
2. Evaluation of project options against the Value Measures.
3. Alectra Utilities' development of the constraints and objectives applied to the portfolio optimization.
4. The financial controls and change management controls relating to the optimized portfolio.

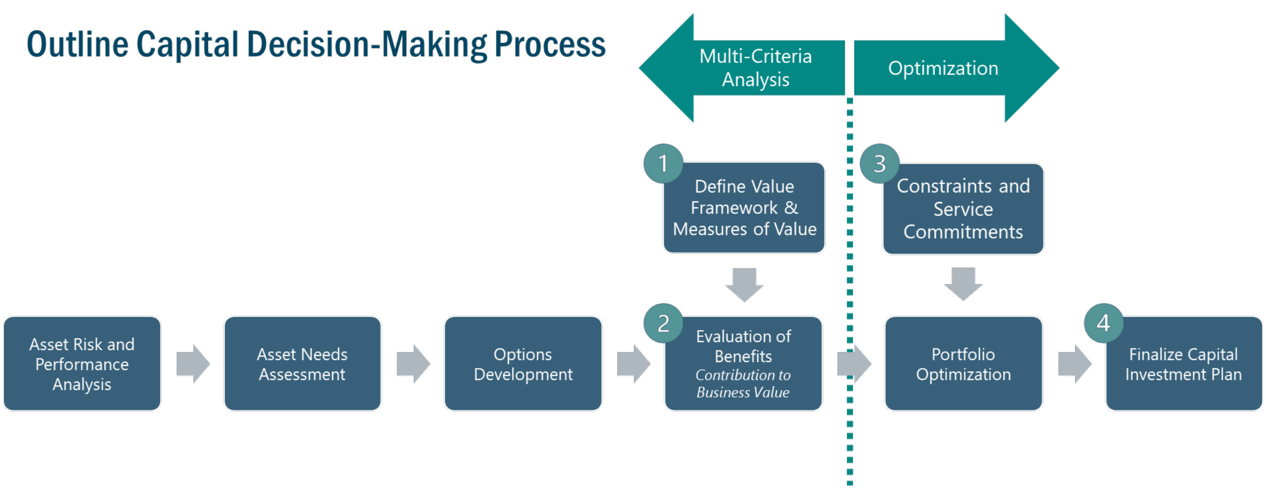

Figure 3 Outline Capital Decision-Making Process - Scope of Assessment

Interviews with members of the Capital Investment Planning Team were held over a period of three weeks. Information provided during the interviews was accepted at face value with no audit trailing.

4. SUMMARY OF FINDINGS

4.1 VALUE FRAMEWORK

4.1.1 Characteristics of Good Practice

Specific requirements for value-based decision-making framework are defined in ISO 55001: 2024 Clause 4.5 Asset management decision-making.[7] In summary, corporate level objectives and performance targets should be defined and organized into a structured and logical decision-making framework, or Value Framework, and these should inform the portfolio optimization and criteria. Activities to improve the breadth and depth of the Value Framework and its application to support effective decision making should be centrally coordinated and actively monitored.

The Value Framework should be disaggregated into "Measures of Value" so that intervention options can be consistently evaluated based on their relative contribution to achieving corporate level objectives and performance targets.

4.1.2 Findings

Alectra Utilities has incorporated the four Outcomes defined by the Ontario Energy Board (OEB) in it's Renewed Regulatory Framework (RRF)[8] for electricity into eight Value Drivers. These Value Drivers have been disaggregated into 23 Value Measures that are quantified using Value Models that are used to evaluate asset interventions.

This ensures proposed capital and operational interventions can be consistently evaluated based on their contribution to achieving the Outcomes defined in the RRF.

Copperleaf is being used to support capital decision making on an enterprise-wide basis including the distribution system, fleet, IT software, hardware etc. The Alectra Utilities Value Framework Definition Document, produced by Copperleaf Technologies Inc., describes the Value Drivers and the Value Measures configured within Copperleaf.

The use and application of Copperleaf, and its administration, is centrally coordinated and is subject to robust change control. The Value Framework has been subject to annual review and improvement over the last 10 years, notable improvements implemented for the current planning cycle include:

- Calibrating the Risk Consequence levels in the Value Framework with the Enterprise Risk Management (ERM) Risk Levels.
- Updating the Project Risk Definition categories to align with the Portfolio Risk Assessment categories.

We conclude Alectra Utilities has developed a comprehensive Value Framework that enables it to demonstrate alignment between the four Outcomes defined in the RRF and Alectra Utilities' 5-year capital plan, and that this is appropriate and consistent with accepted good public utility practice.

[7] (International Organization for Standardization 2024)
[8] Report of the Board - A Renewed Regulatory Framework for Electricity Distributors: A Performance Based Approach

4.2 BUSINESS CAPABILITY

4.2.1 Characteristics of Good Practice

Organizational capability describes the complete set of business activities that an organisation needs to perform, the interdependencies between them and data flows. Typical examples of interdependencies relating to asset decision making include the operational cost impact of capital decision making, capitalization of asset lifecycle renewals and supply chain strategies.

4.2.2 Findings

AMCL reviewed Alectra Utilities' capability in relation to asset investment planning. Alectra Utilities has been developing and improving its asset investment planning capability over the past 10 years, demonstrating a commitment to continual improvement, which is being implemented in a controlled and methodical manner. The Alectra Utilities executive team has an excellent understanding of value-based decision-making and the use and application of the Alectra Utilities Value Framework and have been actively engaged in it's improvement.

4.3 BUSINESS PROCESSES

4.3.1 Characteristics of Good Practice

The business processes and procedures for asset investment planning should be documented in a standard and logical structure and should be centrally coordinated and monitored. Processes should be generally repeatable and consistently applied.

4.3.2 Findings

AMCL reviewed Alectra Utilities' business processes with a focus on those impacting decision-making, specifically the governance and controls associated with business case development and entry, and how the optimization constraints are defined.

Alectra Utilities has implemented a structured, sequential approach to asset investment planning which is well practiced, effective and aligns to accepted industry good practice. Where appropriate[9] and practical to do so, review and approval processes are largely automated through workflows and governance embedded within the Copperleaf software, which ensures process compliance.

[9] *Engineering and technical processes, prior to the identification of asset needs, would normally reside outside capital portfolio planning tools. Examples include network modelling, system design and deterioration modelling.*

4.4 SYSTEMS AND TECHNOLOGY

4.4.1 Characteristics of Good Practice

Most medium to large organizations depend on decision support tools and technologies that inform or enable capital investment planning processes. These tools should be standardized and managed to ensure decision-integrity, ideally by eliminating the manual transfer of data and information between systems.

Good public utility practice is to have asset investment planning practitioners with primary responsibility for the technologies and tools being used to make asset investment decisions and to ensure there is a reasonable level of consistency in how the technology is used.

4.4.2 Findings

Alectra Utilities has a suite of tools to enable asset investment planning activities including asset deterioration modelling, network modelling, portfolio optimization, etc. There is limited integration between the asset planning systems and Copperleaf, but some integration exists between Copperleaf and the finance system.

Specific roles exist at a senior level within the organization with accountability for the management, use and access to Copperleaf, and training ensures a high level of consistency in how the software is used.

4.5 DATA AND INFORMATION

4.5.1 Characteristics of Good Practice

The data and information needed to enable robust, justifiable and transparent asset decision making should be defined, and reflected in Data and Information Strategies and improvement plans. Where data and information needs have not been defined, a set of centrally coordinated activities should be in place to define them.

4.5.2 Findings

The data and information needed to enable robust, justifiable and transparent asset decision making is defined. The outcomes from the optimization process are actively monitored and the findings used to inform future data improvements.

4.6 ORGANIZATION DESIGN

4.6.1 Characteristics of Good Practice

The roles and responsibilities across the various teams and departments contributing to asset planning and decision making should be clear and appropriately resourced. The desired competencies for asset investment planning are defined and embedded into role definitions and job descriptions.

Key process 'hand-off' points between roles and teams throughout the asset investment planning process should be defined, these typically include engineering, planning, strategy and finance.

4.6.2 Findings

AMCL reviewed Alectra Utilities' organizational structure, culture and capability in relation to asset investment planning.

An established team is in place with responsibilities for developing the overall asset investment plan, and this team appears to be well-resourced by competent and capable people. The roles and responsibilities in the various teams and departments (such as Design, Finance, Asset Sustainment) contributing to the asset investment plan is clear.

Team and role level definitions and responsibilities are defined, and individuals have a Personal Development Plan which includes the requirement to develop succession plans.

4.7 CULTURE AND BEHAVIOURS

4.7.1 Characteristics of Good Practice

Nominal 'process owners' should be responsible for reporting regularly on the efficiency and effectiveness of asset investment planning business processes within their area of responsibility; these typically include engineering, planning, strategy and finance.

Contributing individuals should be willing and able to highlight opportunities for improvement when there is a direct and visible impact felt in other parts of the organisation. Asset planning should be considered a business-as-usual activity within the organization, rather than a discrete activity, for example, to support a capital budget application.

4.7.2 Findings

AMCL reviewed Alectra Utilities' organizational structure, culture and capability in relation to asset investment planning.

There is clear ownership for the approach to value-based decision-making within Alectra Utilities; Senior Management understand the investment planning approach, the application of constraints and parameters for the optimization, and are able describe each stage of the analysis, dependencies and sensitivities, in detail.

In general, individual and team behaviors of both internal and consultants, were observed to be collaborative, and a culture of mutual trust and cooperation is apparent.

4.8 BUSINESS RULES AND GOVERNANCE

4.8.1 Characteristics of Good Practice

Business rules and operating principles should be in place that define the how asset expenditure planning activities are performed should be defined, documented and embedded throughout the organization's asset investment planning processes and procedures. Compliance with the processes, and by extension, the business rules and operating principles, should be subject to monitoring and assurance.

4.8.2 Findings

AMCL reviewed Alectra Utilities' business processes with a focus on those impacting decision-making, specifically the governance and controls associated with business case development and entry, and how the optimization constraints are defined.

Measures are in place to maintain the integrity of the planning approach and how it is applied; prior to each planning cycle, Alectra Utilities provides mandatory training to all staff to ensure consistent understanding of the investment planning processes and understanding of the required governance, responsibilities and accountabilities. Specifically, all approvers and authorizers for each process step have been trained on the use of the software and what they are responsible for checking prior to approval.

Overall, the evaluation of investments and investment options against the Alectra Utilities Value Framework is well controlled and being applied consistently across the investment options developed from the various contributors.

5. CONCLUSION

Alectra Utilities uses decision-support software licensed from Copperleaf to support the development of its capital investment portfolio.

AMCL has reviewed the development of Alectra Utilities' Value Framework and how it has been implemented within the Copperleaf solution. We have also reviewed the asset investment planning activities that would influence the outcome of the value-based decision-making approach through the lenses of people, processes and technology.

We concluded that Alectra Utilities has developed a Value Framework that demonstrates clear alignment between the four Outcomes defined by the OEB in the RRF for electricity and its asset decision-making, and that this is both appropriate and consistent with good public utility practice.

Overall, the evaluation of investments and options against the Value Framework is well controlled, based on the best information available to Alectra Utilities and is being consistently applied by contributors across the business.

Based on the information provided [10], we are of the opinion that the Value Framework, as configured within Copperleaf, can be trusted to inform business decision-making in a manner consistent with both the OEB Outcomes and Alectra Utilities' corporate objectives and performance targets.

[10] *Information provided to AMCL was taken at face value with no audit trailing.*

APPENDICES

Appendix A ACRONYMS & ABBREVIATIONS

Abbreviation	Description
AIP	Asset Investment Planning
AM	Asset Management
AMCL	The consultant engaged for this AM maturity assessment
C55	Copperleaf C55, a software application deployed to optimize asset investment portfolio
GFMAM	Global Forum on Maintenance & Asset Management
IAM	Institute of Asset Management
ISO 31000	A set of international standards governing risk management
ISO 5500x	A set of international standards governing asset management ISO 55000 - 2024 provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management. ISO 55001 - 2024 specifies requirements for an asset management system within the context of the organization. ISO 55002 – 2014 gives guidelines for the application of an asset management system, in accordance with the requirements of ISO 55001
PPM	Planned Preventive Maintenance
SAMP	Strategic Asset Management Plan
ToR	Term of Reference

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Appendix E

Asset Condition Assessment Report

2023

Discover the possibilities

Asset Condition Assessment - 2023

ASSET MANAGEMENT

2023 ACA REPORT

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Executive Summary

Overview

The 2023 Asset Condition Assessment (ACA) report incorporates comprehensive data as of year end 2023, leveraging data analytics and rigorous inspection protocols to develop an in-depth understanding of asset health. Partnering the ACA with other Asset Management practices enables strategic investment decisions to drive prudent risk management.

The findings presented in this report underscore the critical need for investments in Alectra's distribution system. Alectra's assets continue to degrade and face increasing operational demands. This comprehensive assessment provides compelling evidence to support proposed capital investments that are essential for maintaining a robust and reliable electrical distribution system.

This ACA Report benefitted from enhancements made in recent years with key achievements listed below:

- Harmonized inspection practices
- Data-driven decision-making framework
- Enhanced analytics processes

ACA Process

Asset Management practices demonstrate a commitment to maintaining service excellence. Alectra employs the Health Index methodology to classify the health of assets into one of the following categories:

- **Very Poor**: Assets showing major degradation or critical condition demanding urgent intervention.
- **Poor**: Assets exhibiting significant degradation requiring attention.
- **Fair**: Assets functional but showing clear signs of deterioration.
- **Good**: Assets in working condition with minimal signs of deterioration.
- **Very Good**: Assets with no signs of deterioration.

This assessment framework supports strategic Asset Management decisions and optimal allocation of resources.

ACA Results

Alectra’s Asset Management process exemplifies Alectra's commitment to comprehensive infrastructure management with a holistic approach to ensure infrastructure investments are strategically aligned with both current operational demands and future system requirements, demonstrating Alectra’s commitment to maintaining a resilient and reliable electrical distribution network.

Subject Matter Experts (e.g., Engineers) utilize a multi-faceted decision-making framework that integrates Health Index metrics with the following additional considerations to inform sustainment strategies:

- Strategic initiatives (e.g., voltage conversion, storm hardening)
- Critical load assessment and customer impact analysis
- System expansion requirements
- Load transfer capabilities
- Equipment obsolescence management
- Parts availability and maintainability considerations
- Safety and environmental compliance
- Investment coordination optimization

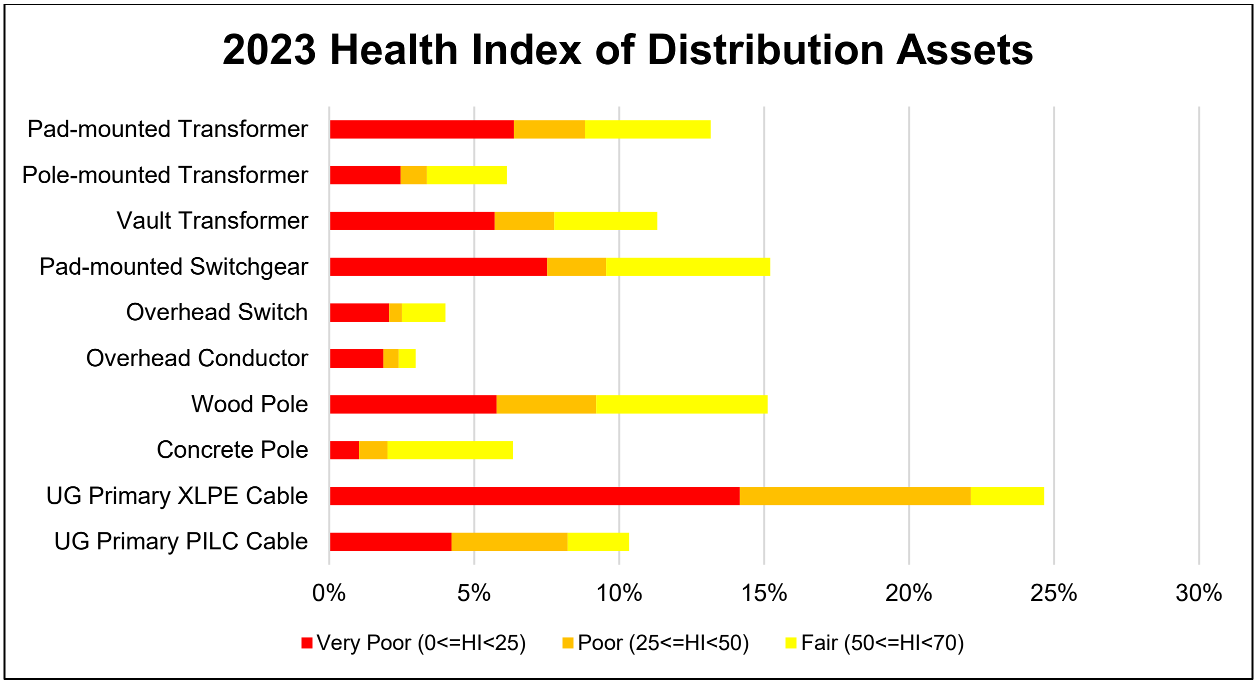
The resulting sustainment strategies are then optimized through Copperleaf C55, adhering to Alectra’s Value Framework.

Alectra classifies its assets into two main categories: Distribution assets and Station assets.

Distribution Assets: Alectra’s distribution network encompasses these four critical asset classes, each monitored through a Health Index framework:

- Transformers (pad-mounted, pole-mounted, and vault-type)
- Switching equipment (pad-mounted switchgear and overhead load interrupting switches)
- Poles and conductors
- Underground cables

The following chart illustrates the proportion of distribution assets in deteriorating condition (i.e., with HI less than 70%). A significant portion of Alectra’s distribution infrastructure, such as underground cables, wood poles, switchgear, and transformers, are shown to be in the Very Poor and Poor Health Index condition categories.

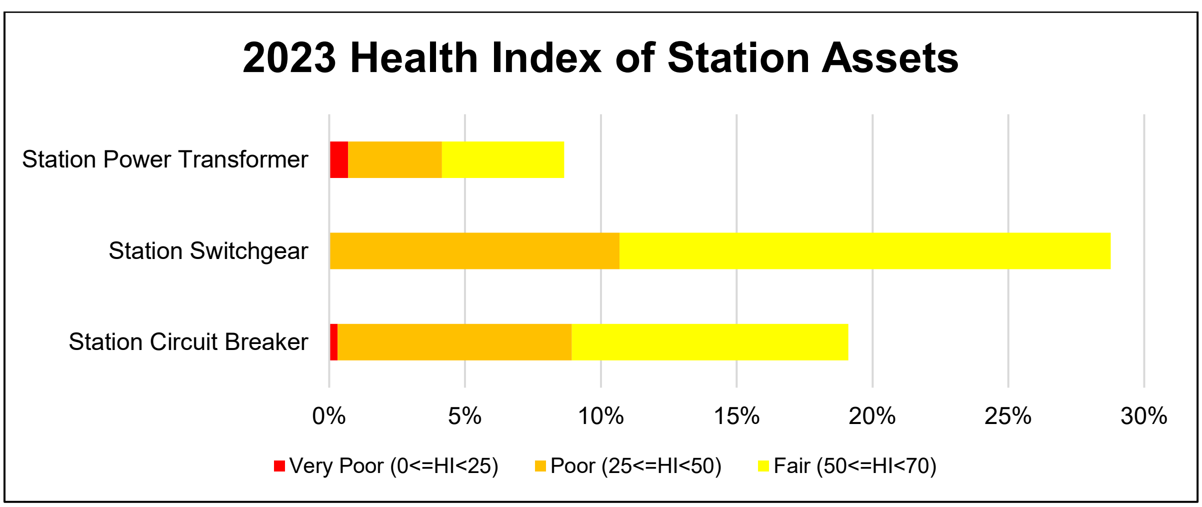


Distribution Asset Health Index Results Summary for 2023

Station Assets: Alectra's station infrastructure portfolio encompasses these three main critical asset categories:

- Power transformers
- Station-class switchgear
- Circuit breakers

The following chart illustrates the proportion of Alectra's critical station assets in deteriorating condition (i.e., with HI less than 70%).

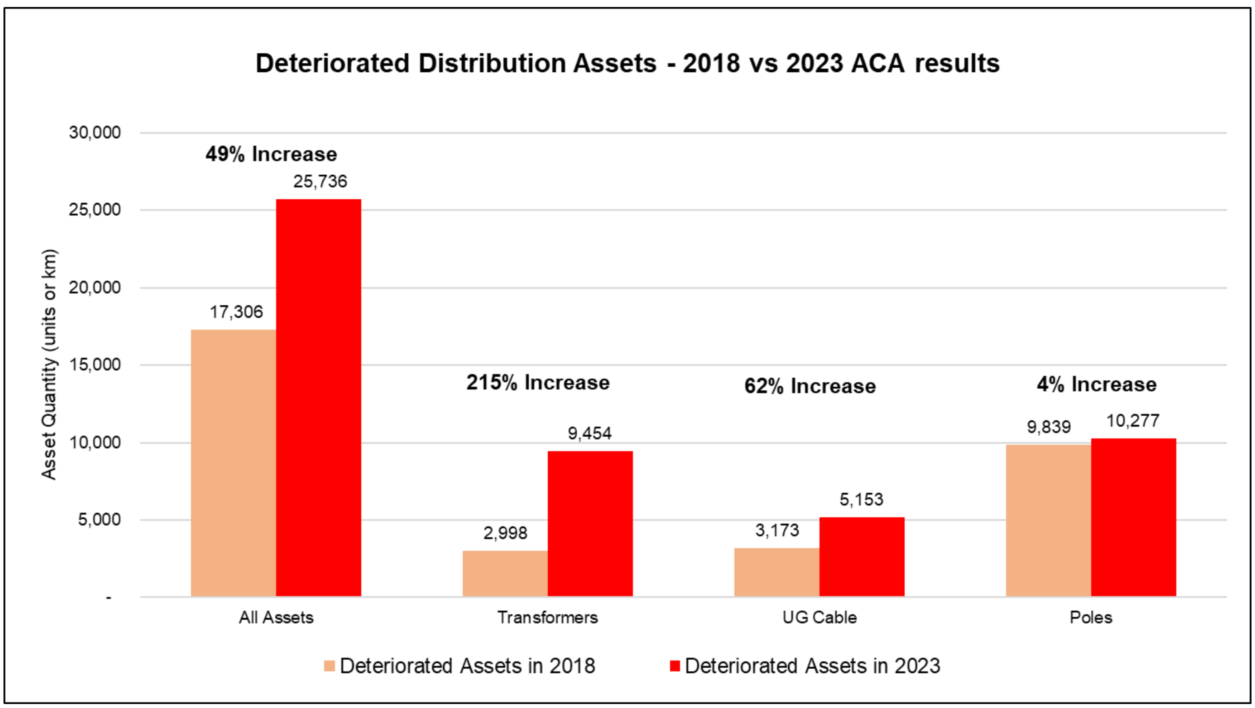


Station Asset Health Index Results Summary for 2023

Conclusions and Recommendations

Alectra's 2023 Asset Condition Assessment highlights ongoing deterioration of major assets. Alectra's Health Index methodology has revealed that significant portions of its distribution and station assets, particularly distribution transformers, underground cables, and overhead assets, require urgent intervention.

Compared to the previous Distribution System Plan (DSP) period, the total percentage of distribution assets in deteriorated condition (Very Poor and Poor HI category) has increased by 49%. Most notably, as illustrated in the chart below, the total percentage of deteriorated assets has increased by 215% for distribution transformers, 62% for underground cables, and 4% for poles since 2018. This increase underscores the urgency for addressing the increased number of deteriorated distribution assets, as sustainment needs have increased substantially compared to the previous DSP period.



Comparative Deteriorated Assets for Dx Transformers, UG Cables, and Poles (2018 vs 2023 ACA)

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1 Introduction

This Asset Condition Assessment (ACA) report is used to identify and address sustainment investment requirements as part of Alectra's Asset Management practices.

The 2023 ACA builds on previous condition assessments, incorporating condition and inventory information available as of year end 2023, using similar practices that were harmonized in 2018 after Alectra's formation.

ACA is an internal process used by Alectra as part of the overall Asset Management process. Outputs from the ACA are evaluated for sustainment needs. Figure 1 summarizes the Asset Management process in which ACA is used as one of input to identify investment needs.

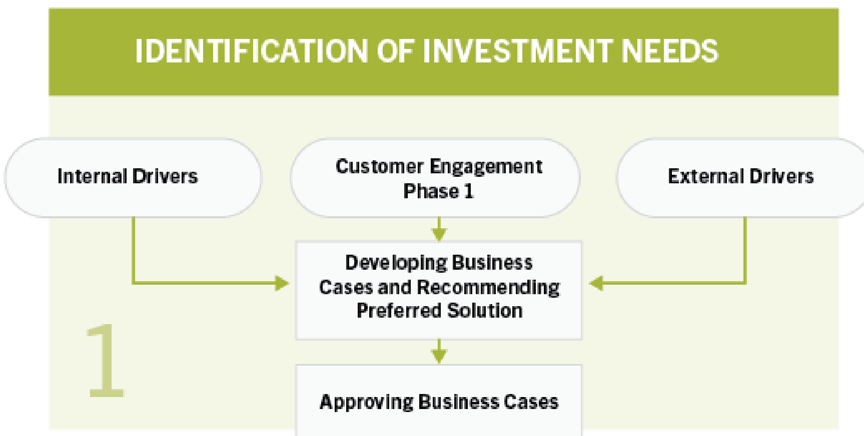

Figure 1 Asset Management Process Investment Drivers and Considerations

This report describes an analytical approach to asset condition assessment for Alectra's distribution and station assets using Health Indices. Alectra's Asset Management process leverages expertise of SMEs (e.g.,Engineers) that translate Health Index data into actionable sustainment strategies. SMEs employ a multi-faceted decision-making framework that goes beyond basic Health Index metrics to consider the following factors:

- Strategic initiatives (e.g., voltage conversion, storm hardening)
- Critical load assessment and customer impact analysis
- System expansion requirements
- Load transfer capabilities
- Equipment obsolescence management
- Parts availability and maintainability considerations

- Safety and environmental compliance
- Investment coordination optimization

Where needs warrant sustainment activities, business cases are documented in Copperleaf C55, integrating all applicable cross-functional drivers as part of Alectra's integrated planning.

Figure 2 illustrates the process for identifying investment needs for both distribution and station assets.

Figure 2 Asset Management Process

Capital investment portfolio optimization is completed in Copperleaf C55, where investments are optimized across all Alectra investment categories. The optimization considers the risk and benefit in conjunction with financial attributes.

The asset evaluation process exemplifies Alectra's commitment to comprehensive infrastructure management with a holistic approach to ensure infrastructure investments are aligned with both current operational demands and future system requirements, demonstrating Alectra's commitment to maintaining a resilient and reliable electrical distribution network. These strategies are then optimized through Copperleaf C55, adhering to Alectra's Value Framework.

2 ACA Data and Implementation

Since 2018, Alectra's commitment to continuous improvement and advanced analytics has led to harmonized inspection practices for both distribution and station assets. This section highlights improvements.

2.1 Analytics

Alectra's Asset Condition Assessment (ACA) is facilitated by a Relational Database Management System that uses Structured Query Language (SQL) for reliable and efficient data storage and retrieval. In 2021, Alectra adopted Alteryx to further strengthen its data processing, analytical workflows, and overall asset data quality.

Together, the implementation of these technologies enabled the following advantages:

- **Integrating multiple data sources** enables the integration of multiple static data sources while maintaining data integrity and consistency in the transfer process.
- **Centralized storage** provides a common repository for the required ACA data and calculations.
- **Multiple user access** allows for simultaneous access by multiple users, thus providing significant contribution to productivity.
- **Version control** enables future assessments while maintaining a high level of productivity, data accuracy and benchmarking functionality.
- **Development agility** enables fast and accurate future improvements/development to the ACA data, models, and computations.

2.2 Distribution Asset Inspection Practices

Alectra completed the Geographical Information System (GIS) convergence project in 2021, consolidating four legacy datasets and related workflows into one standardized GIS application. This application supported a mobile asset inspection solution, MobileViewer Advantage (MVA), that is linked directly to GIS. This linkage enabled tying inspection records to a unique asset Feature Identifier (FID) in GIS, providing a centralized location for validated inspection records. These inspection records can be reviewed by SMEs and are extracted for utilization in ACA.

Alectra refined the inspection attribute specification and completed a 3-year inspection cycle (2021-2023) using MVA to collect granular asset condition data. This data is used to prioritize assets for corrective action, refurbishment, or replacement. Alectra will continue inspecting assets on set cycles, as per regulations, and continue updating inspection records and condition data. SMEs leverage the data collected through inspections to ensure appropriate sustainment strategies are employed.

3 ACA Methodology

ACA models quantify the condition of an asset in a consistent manner by computing Health Indices. Each asset class has different inputs to inform the HI model. The input weights are based on the asset's characteristics, the extent to which the input reflects asset degradation, industry guidelines, and Alectra's experience. Health Index model formulas, parameters, inputs, and results are stored in the Relational Database Management System, enabling a unified source for performing HI computations and providing the agility for future enhancements. Figure 3 displays a flowchart summarizing the HI methodology.

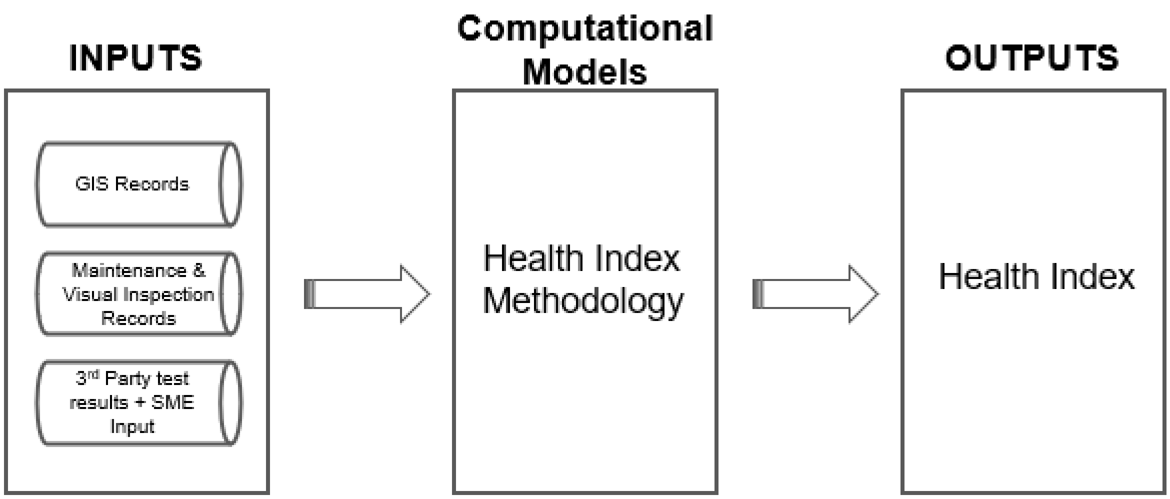

Figure 3 Health Index Methodology: Inputs, Computation, and Outputs

The standardized model for assets across Alectra ensures that all assets are being measured in a consistent manner to guide Asset Management strategies and practices. The generic equation below provides the calculation method of the Health Index, while the asset specific inputs will be listed in subsequent sections in the report.

$$\boldsymbol{Health\ Index} = \frac{\sum_{i=1}^{n}(Input\ Weight_{\,i} \times\ Input\ Score_{\,i}\,)}{\sum_{i=1}^{n}(Input\ Weight_{\,i}\,)} * Condition\ Multiplier \qquad (\mathbf{2})\ ,\ \ where$$

$$\boldsymbol{n}: number\ of\ available\ inputs\ for\ an\ asset\ class,$$

$$\boldsymbol{Input\ Score}: percentage\ (0 - 100\%)\ ,$$

$$\boldsymbol{Health\ Index}: percentage\ (0 - 100\%),$$

$$\boldsymbol{Input\ Weight}: percentage, where \sum_{i=1}^{n} Input\ Weight_{\,i} = 100\%$$

$$\boldsymbol{Condition\ Multiplier}: a\ delimiter\ to\ be\ applied\ to\ the\ HI\ that\ caps\ the\ maximum\ HI\ value\ for\ an\ asset, based\ on\ a\ specific\ condition\ metric$$

3.1 Input Score

Inputs to the Health Index are scored in one of two ways, a step score, or a percentage score. Each input that makes up the Health Index is scored accordingly.

3.1.1 Step Score

Step Score is a discrete points-based scoring method used in Health Index calculations to evaluate non-continuous condition inputs, such as field inspections, by categorizing them into distinct levels based on predefined criteria. Station assets and distribution assets are inspected and monitored through asset-specific processes and scoring criteria.

Distribution Assets: Field inspections and HI components that use step scoring for distribution assets have a four-level inspection scoring (0-5). Table 1 provides a generic distribution asset step scoring criteria and associated scores in percentage.

Table 1 Generic Distribution Asset Step Scoring

Inspection Score	Criteria	HI Input Score
5	No Issue/Good	100%
3	Minor Issue	60%
1	Moderate Issue	20%
0	Major Issue	0%

Station Assets: Field inspections and Health Index components that use step scoring for station assets have a five-level scoring system (0-4). Table 2 provides the station asset step scoring criteria and associated scores in percentage.

Table 2 Station Asset Step Scoring

Inspection Score	Criteria	HI Input Score
4	Excellent - Like new	100%
3	Good - Within operating context	75%
2	Fair - Not failed but monitoring	50%
1	Poor - Not within operating context	25%
0	Very Poor - Imminent failure	0%

3.1.2 Percentage Score

Percentage scoring is the continuous (i.e., graduated) scoring of an input. Percentage scoring is used when more granular data is available. This method is used for certain measurements, such as pole residual remaining strength, as well as for other data, such as age.

Age is represented as a percentage score based on a continuous function given by the Gompertz-Makeham Model described by the following set of equations:

$$Age\ score = e^{\frac{-(f(t)-e^{-\alpha\beta})}{\beta}} \qquad \mathbf{(3)} \quad ,where$$

$$f(t) = e^{\beta(t-\alpha)}, where$$

$$t: age\ (years)$$

$$\alpha, \beta: \text{constants}$$

The constants α, β are calculated to yield an age score of 80% at the Typical Useful Life (TUL), and 1% at the End of Useful Life (EUL) of an asset. Use of the Gompertz-Makeham Model is a widely accepted industry practice for assessing asset condition.

Asset TUL is based on the “Asset Depreciation Study for the Ontario Energy Board Kinectrics Inc. Report No: K-418033-RA-001-R000 July 8, 2010” report. Similarly, asset EUL is based on the Maximum Useful Life (Max UL) from the same report.

3.2 Condition Multiplier

Conditions that determine degradation or imminent failure of an asset not accounted for by the calculated HI are accounted for by limiting the HI to a maximum value using the condition multiplier. Once certain conditions are triggered, the HI of an asset is limited to a maximum score, regardless of the status of other inputs.

Condition multipliers are based on dominant HI inputs that significantly impact the asset's health. For example, pole remaining strength is a strong indicator of a wood pole's health.

Examples of the types of condition are as follows:

- **Safety hazard multiplier** is applied to assets that pose a safety hazard or in a condition that is below the acceptable industry safety standards, guidelines, and practices. Examples include Accelerated Degradation Multiplier for air-insulated switchgear, Restricted Conductor Size Multiplier for overhead conductors, and Explosive Gas Multiplier for power transformers.
- **Field inspection multiplier** is applied to assets that exhibit significant degradation or imminent failure as determined by field inspection.
- **Measurement multiplier** is applied to assets that exhibit major degradation or imminent failure as determined by a test measurement. Examples include Pole Remaining Strength Multiplier for wood poles and DGA Multiplier for power transformers.

Where two or more condition multipliers are applicable, the smallest multiplier (by value) is applied.

3.3 Health Index Categorization

The Health Index of assets is expressed as a percentage, with a maximum value of 100. Health Index is classified into one of five categories, as described in Table 3.

Table 3 Health Index Categories

Category	Criteria	Range
Very Good	Assets with no signs of deterioration.	$HI \geq 85\%$
Good	Assets in solid working condition with minimal signs of deterioration.	$70\% \leq HI < 85\%$
Fair	Assets functional but showing clear signs of deterioration.	$50\% \leq HI < 70\%$
Poor	Assets exhibiting significant degradation requiring attention.	$25\% \leq HI < 50\%$
Very Poor	Assets showing major degradation or critical condition demanding urgent intervention.	$HI < 25\%$

Categorization based on percentage ranges enables the identification of groups within an asset class that exhibit similar characteristics from an overall condition perspective. A bar chart illustrating the five Health Index categories as a function of HI score is presented in Figure 4.

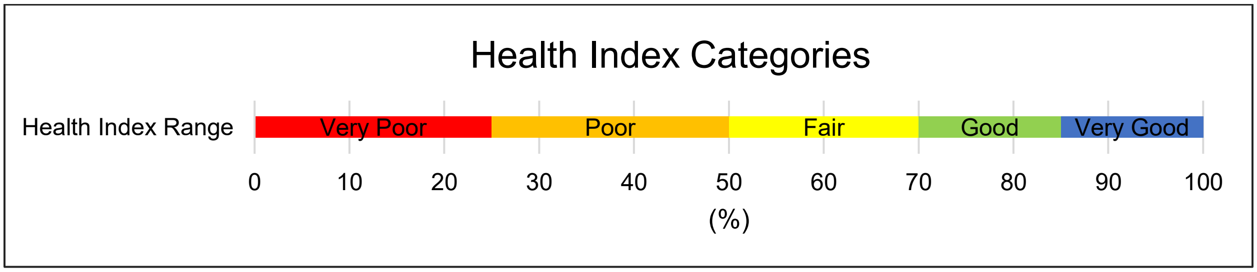

Figure 4 Health Index Categories

4 System Sustainment Strategies

The Asset Condition Assessment (ACA) identifies assets within each asset class that require action. System sustainment strategies are dependent on the type of asset, consequences of failure, and Asset Management practices. These strategies are:

1. Planned replacement,
2. Maintenance or rehabilitation,
3. Continue to monitor, and
4. Run to failure.

1. Planned replacement approach applies to critical assets that carry significant risk to the safe and reliable operation of the distribution system and protection of the environment. Safety considerations include safety of both the public and distribution system workers (Alectra's employees and contractors). For example, failure of wood and concrete poles carries significant safety risk to the public; therefore, a planned replacement strategy is prudent.

2. Maintenance or rehabilitation strategy applies to assets where only certain components of the asset are exhibiting degradation that can be corrected by cleaning or washing, repairing, replacing, or re-tightening of components, or utilizing technologies such as cable rejuvenation. For example, dirty insulators in air-insulated switchgear may be remedied by dry-ice cleaning.

3. Continue to monitor applies to assets where condition is approaching what is typically considered to be its end of life. This strategy is also applicable to assets that have been replaced or maintained and were determined to be in safe and reliable condition. Monitoring strategies involve maintaining or increasing asset inspection cycles and/or installing on-line monitoring, such as on power transformers. Transformer on-line monitoring, in conjunction with analytical tools, can provide an indication of the condition of the transformer's insulation, which is a primary indication of the transformer's health. Adoption of on-line monitoring and associated analytical tools, in conjunction with the development of a modified condition-based maintenance protocol, is a strategy for prolonging the operational life of a transformer.

4. Run to failure applies to assets having minimal impact on reliability, on public or employee safety, and on the environment. Such assets are run to failure and are replaced reactively when they no longer perform their intended function. The decision to run to failure considers redundancy, contingencies, and availability of spare units or components.

Stations asset investments follow a risk-based approach to identify specific asset sustainment initiatives. SMEs consider multiple factors along with the HI results for individual components. The sustainment strategies for station assets are primarily guided by risk mitigation and not pacing/timing.

5 Distribution Asset Class Details and Results

Alectra's distribution asset details are described in terms of asset degradation, demographics, and Health Index (HI) results categorization. Health Index is calculated for the distribution asset classes listed below:

- Distribution transformers
- Distribution switchgear
- Overhead switches
- Overhead conductors
- Wood poles
- Concrete poles
- Underground primary cables

5.1 Distribution Transformers

Distribution transformers are a vital component to serving customers from the distribution system at utilization voltages. Distribution transformers are moderately complex assets with a varying price per unit.

5.1.1 Summary of Asset Class

Distribution transformers include three types: Pad-mounted, Pole-mounted, and Vault. Distribution transformers convert primary distribution voltages to secondary voltages (utilization voltages) for use in residential and commercial applications.

5.1.1.1 Pad-mounted Transformers

Pad-mounted transformers connect customers to the distribution system where service laterals are underground. Pad-mounted transformers typically employ sealed-tank construction and are liquid filled, with mineral oil being the predominant insulating medium.

5.1.1.2 Pole-mounted Transformers

Pole-mounted transformers, also known as overhead transformers, connect customers to the distribution system where service laterals are overhead. This type of transformer is mounted on wood or concrete poles. Pole-mounted transformers include single-phase transformers, banked single-phase transformers, and three-phase (polyphase) transformers.

5.1.1.3 Vault Transformers

Vault transformers are similar to pole-mounted transformers in construction, but are designed to be placed in chambers, either below or on grade, or in rooms inside buildings. This category includes submersible transformers. Vault transformers connect customers to the distribution system where service laterals are underground.

5.1.2 Asset Degradation

Distribution-class transformer condition is affected by several factors including, but not limited to, the following: Voltage impulses from lightning and switching, Current surges resulting from secondary cable faults, Mechanical damage from vehicle contact, Overloading, and Environmental factors (e.g., ambient temperature and exposure to road salts). Field inspection attributes criteria are used to determine the health of the asset.

The failure of a distribution transformer can pose a risk to the safety of the public or to the environment (i.e., oil leak leading to costly clean-up); hence, a planned replacement strategy is executed for imminent failure risk or hazardous conditions.

5.1.3 Asset Class Demographics

Alectra's distribution system has 128,362 distribution transformers, comprised of pad-mounted, pole-mounted, and vault transformers.

5.1.3.1 Pad-mounted Transformers

Alectra's distribution system has 83,885 pad-mounted transformers. Figure 5 illustrates the age distribution of pad-mounted transformers. 5,313 pad-mounted transformers are shown to exceed the TUL of 40 years, of which 2,029 exceed the EUL of 45 years, representing 6.3% and 2.4%, respectively, of the total installed population.

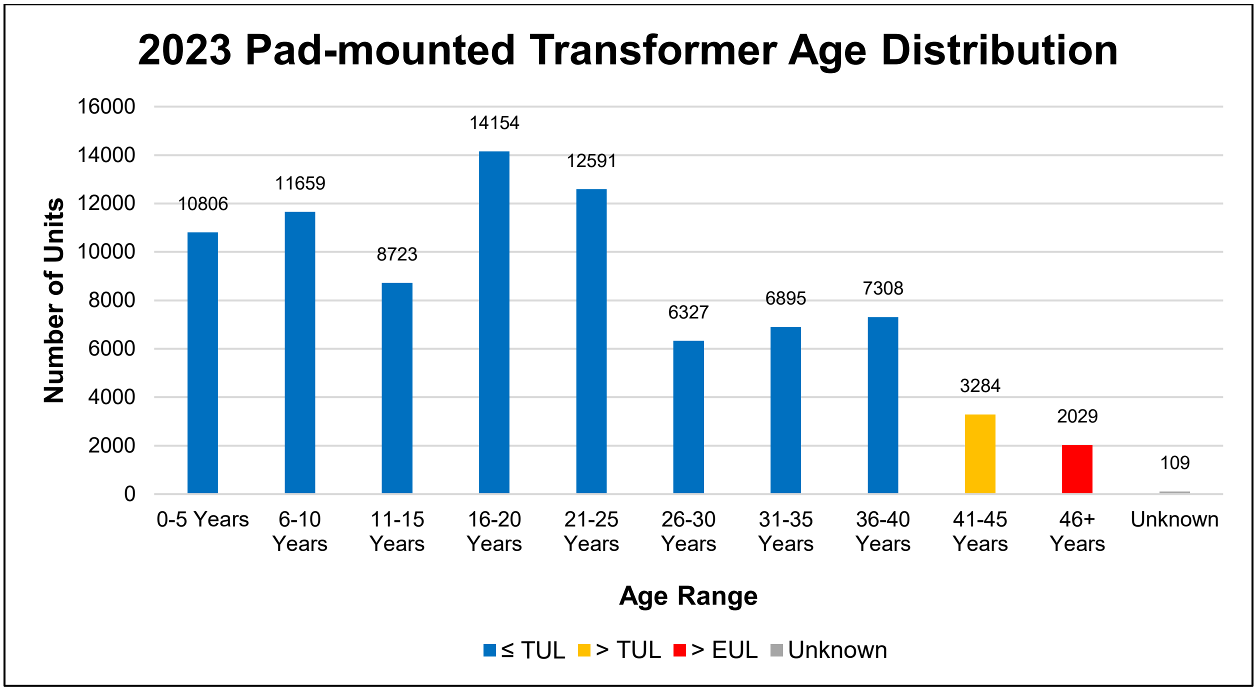

Figure 5 Pad-mounted Transformer Age Distribution for 2023

5.1.3.2 Pole-mounted Transformers

Alectra's distribution system has 31,807 pole-mounted transformers. Figure 6 illustrates the age distribution of pole-mounted transformers. 3,150 pole-mounted transformers are shown to exceed the TUL of 40 years, of which 259 exceed the EUL of 60 years, representing 9.9% and 0.8%, respectively, of the total installed population.

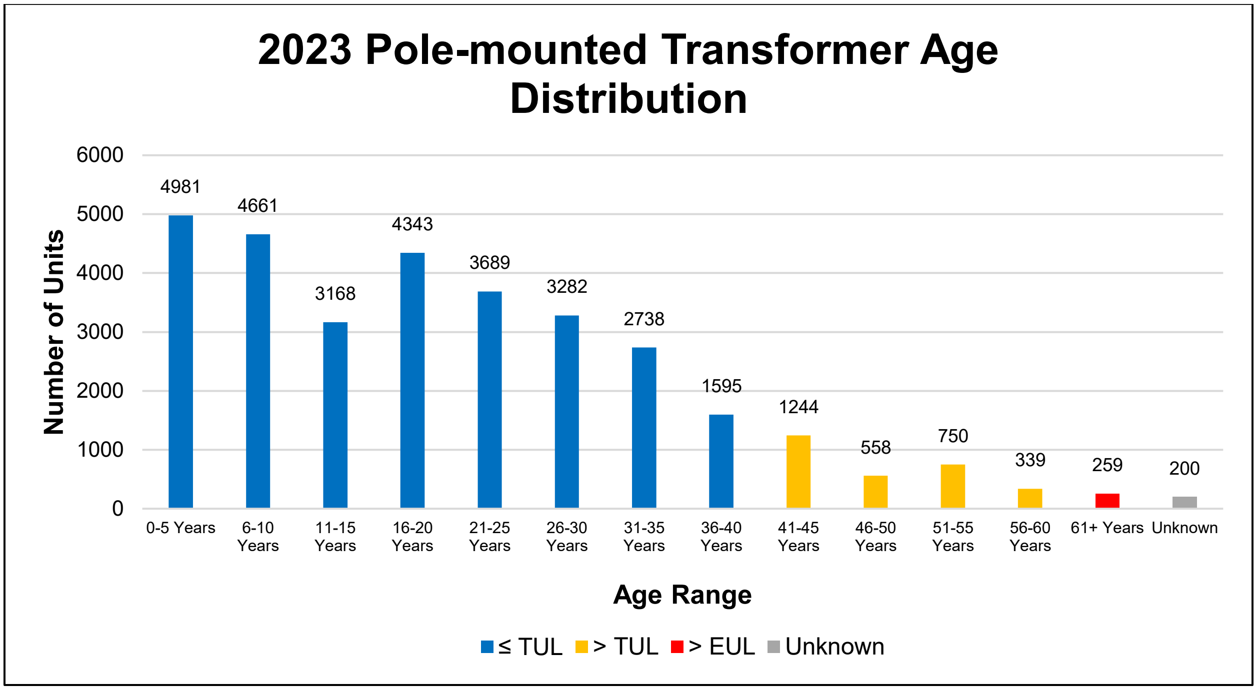

Figure 6 Pole-mounted Transformer Age Distribution for 2023

5.1.3.3 Vault Transformers

Alectra's distribution system has 12,670 vault transformers. Figure 7 illustrates the age distribution of vault transformers. 5,224 vault transformers are shown to exceed the TUL of 35 years, of which 1,212 exceed the EUL of 45 years, representing 41.2% and 9.6%, respectively, of the total installed population.

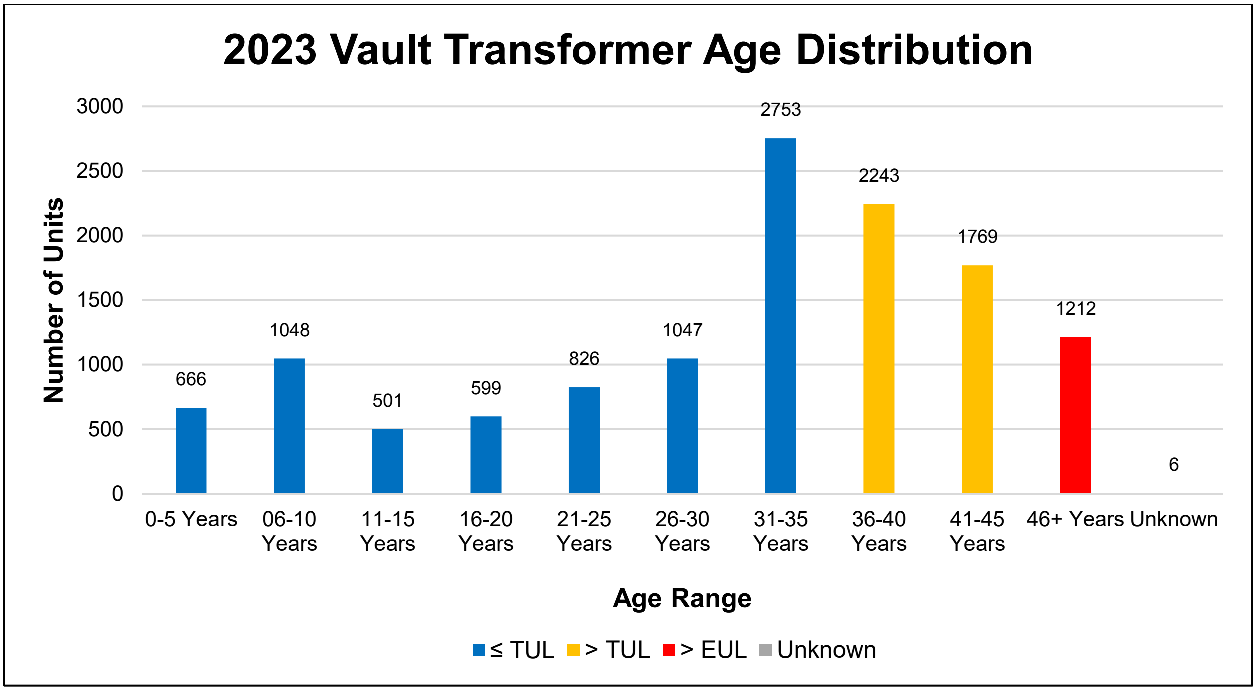

Figure 7 Vault Transformer Age Distribution for 2023

5.1.4 Health Index Formula and Results

Health index of distribution transformers assesses the condition according to three components: Corrosion, Oil leak, and Age. Severity of corrosion and oil leak are determined through inspections and are scored as a step score.

Age represents deterioration due to factors not captured by the other components of the model. The scoring method for age is described in *Section 3.1.2 Percentage Score*. The Health Index is computed by adding the weighted inputs of corrosion, oil leak and age, as indicated in Table 4.

Table 4 Distribution Transformer Health Index Parameters and Weights

#	Input	Pad-mounted Transformer	Pole-mounted Transformer	Vault Transformer	Scoring Method
1	Corrosion	44%	35%	25%	Step Score
2	Oil Leak	44%	35%	61%	Step Score
3	Age	12%	30%	14%	Percentage Score

Field Inspection Multiplier

If a distribution transformer exhibits significant degradation or imminent failure, as determined by field inspection, it is considered to be of Very Poor health and will have a maximum Health Index of 25% (i.e., the calculated Health Index is multiplied by 0.25). The physical conditions considered in this criterion are major and moderate oil leak or corrosion.

5.1.4.1 Pad-mounted Transformers

Figure 8 illustrates the Health Index distribution of pad-mounted transformers, classified from Very Poor to Very Good. 7,401 pad-mounted transformers are shown to be in the Very Poor or Poor category.

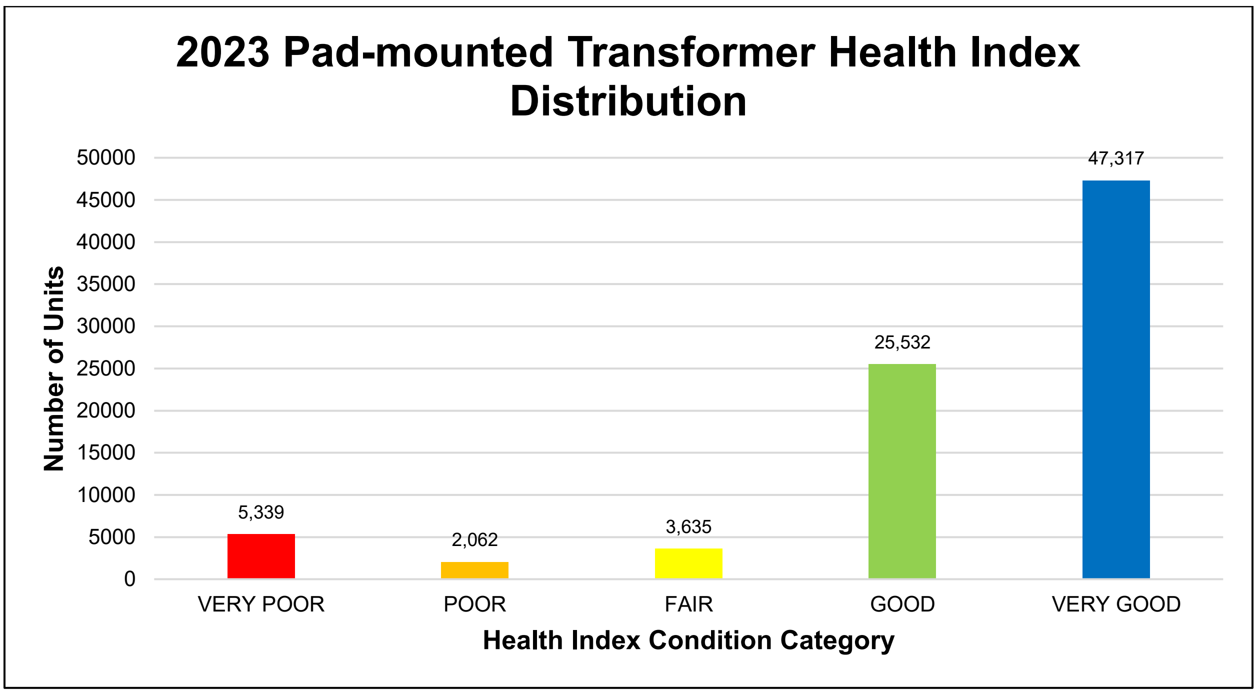

Figure 8 Pad-mounted Transformer Health Index Distribution for 2023

Alectra has managed deteriorating pad-mounted transformers through a combination of proactive and reactive replacement strategies. An increase in sustainment pacing is required to address the increasing level of deteriorated transformers and to mitigate safety, reliability, and environmental risks to a level that is satisfactory for both customers and Alectra.

5.1.4.2 Pole-mounted Transformers

Figure 9 illustrates the Health Index distribution of pole-mounted transformers, classified from Very Poor to Very Good. 1,070 pole-mounted transformers are shown to be in the Very Poor or Poor category.

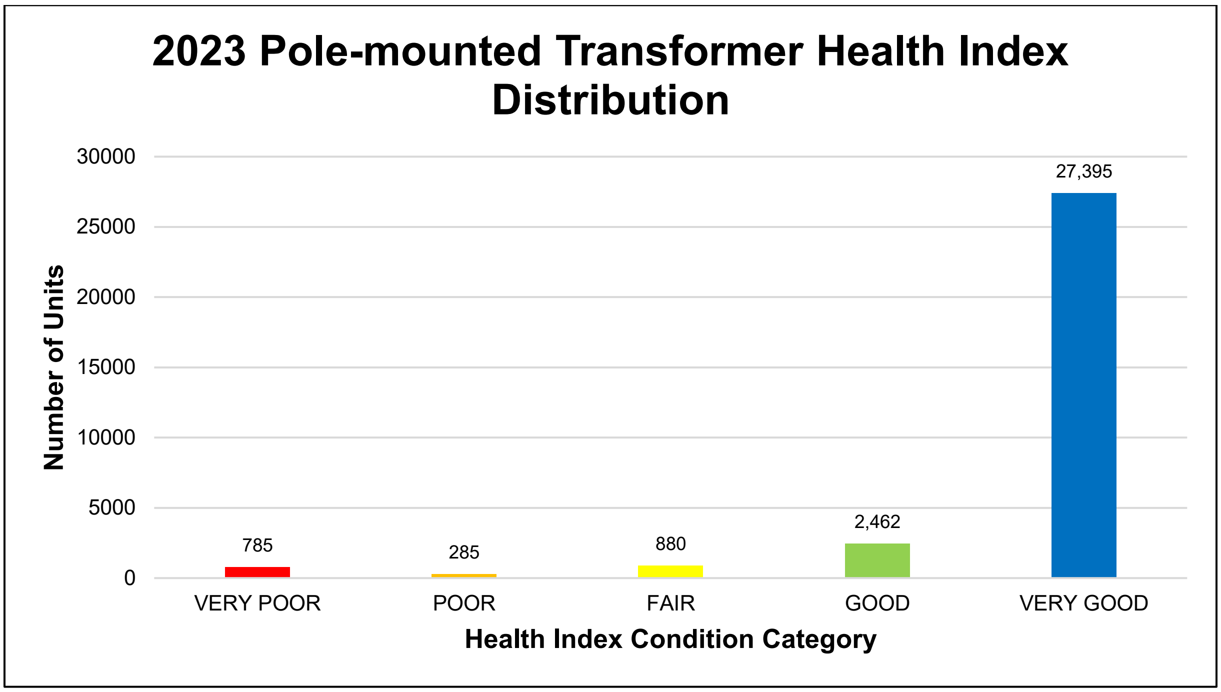

Figure 9 Pole-mounted Transformer Health Index Distribution for 2023

Alectra employs a multi-faceted decision-making process that goes beyond basic Health Index metrics for replacing pole-mounted transformers, including environmental compliance.

5.1.4.3 Vault Transformers

Figure 10 illustrates the Health Index distribution of vault transformers, classified from Very Poor to Very Good. 983 vault transformers are shown to be in the Very Poor or Poor category.

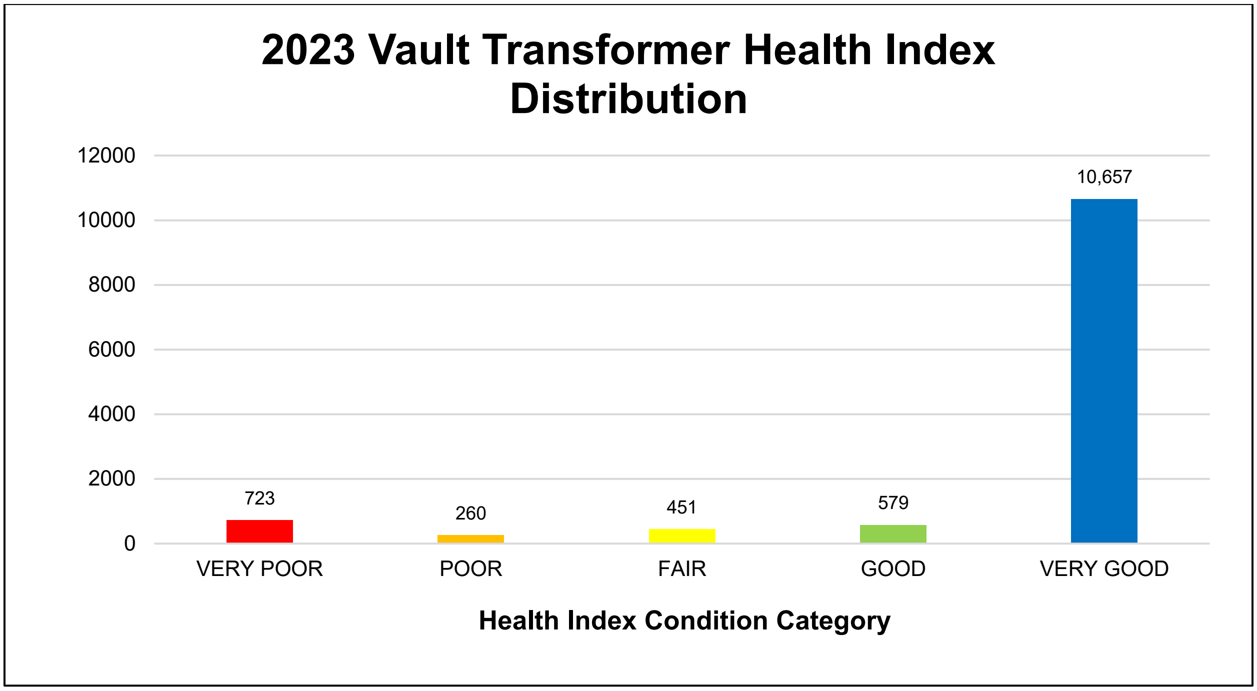

Figure 10 Vault Transformer Health Index Distribution for 2023

Failure to proactively replace vault transformers elevates the risk of prolonged outages experienced by customers (e.g., apartment buildings) and may pose unsafe conditions. Many vault transformers are unable to be replaced like-for-like due to older construction standards and installations requiring complex conversion.

5.2 Distribution Switchgear

5.2.1 Summary of Asset Class

Pad-mounted switchgear units are used in the underground distribution system to facilitate the connection of local distribution circuits from main-line underground feeder cable systems, as well as to interconnect main-line feeder circuits. Switchgear provide fused connection points for residential subdivisions and commercial/industrial customers. Switchgear units are used for isolating, sectionalizing, fusing for laterals, and reconfiguring cable loops for maintenance, restoration, and other operating requirements. A single switchgear failure can impact as many as 5,000 customers.

There are four types of distribution switchgear used in Alectra's distribution system: Air-insulated, Oil-filled, Solid-dielectric, and SF_6 switchgear.

SF_6 is a very potent greenhouse gas, having a global warming potential of approximately 23,500 times that of carbon dioxide[1]. Alectra addresses SF_6 leaks with high importance. When a leak is detected, units are repaired or are replaced reactively with an alternate switchgear type, if technically feasible.

5.2.2 Asset Degradation

Switchgear aging and eventual end of life are often established by mechanical failures, such as rusting of the enclosures or ingress of moisture and dirt into the switchgear, causing corrosion of operating mechanism and degradation of insulation.

To extend the life of these assets and to minimize in-service failures, sustainment practices are employed, including inspection with thermographic analysis and cleaning with CO_2 for air insulated pad-mounted switchgear.

Failures of distribution switchgear are typically associated with external influences. For example, pad-mounted switchgear is most likely to fail due to dirt/contamination, vehicle accidents, rusting of the enclosure, rodents, and broken insulators caused by misalignment during switching. Failures caused by fuse malfunctions can result in a catastrophic switchgear failure.

Automated switchgear have the same construction as pad-mounted switchgear, but with the addition of motorized remote switch controls. Automated switchgear have the same degradation mechanism as pad-mounted switchgear. In addition, failure of motor and/or its control may contribute to the end of life of the switchgear.

5.2.3 Asset Class Demographics

Alectra's distribution system operates 3,444 pad-mounted switchgear, with varying insulation types, namely, air, solid dielectric, SF_6, and oil. According to industry averages, pad-mounted switchgear have a TUL of 30 years and an EUL of 45 years. However, air-insulted switchgear operating on the 27.6 kV system have different operating lifecycle. Based on Alectra's and industry experience, the TUL for these units is 20 years and EUL is 35 years. Figure 11 illustrates the age distribution of all pad-mounted switchgear. 447 of all pad-mounted switchgear are known

[1] United Nations Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5)

to exceed the TUL, of which 51 exceed the EUL, representing 13% and 1.5%, respectively, of the total installed population.

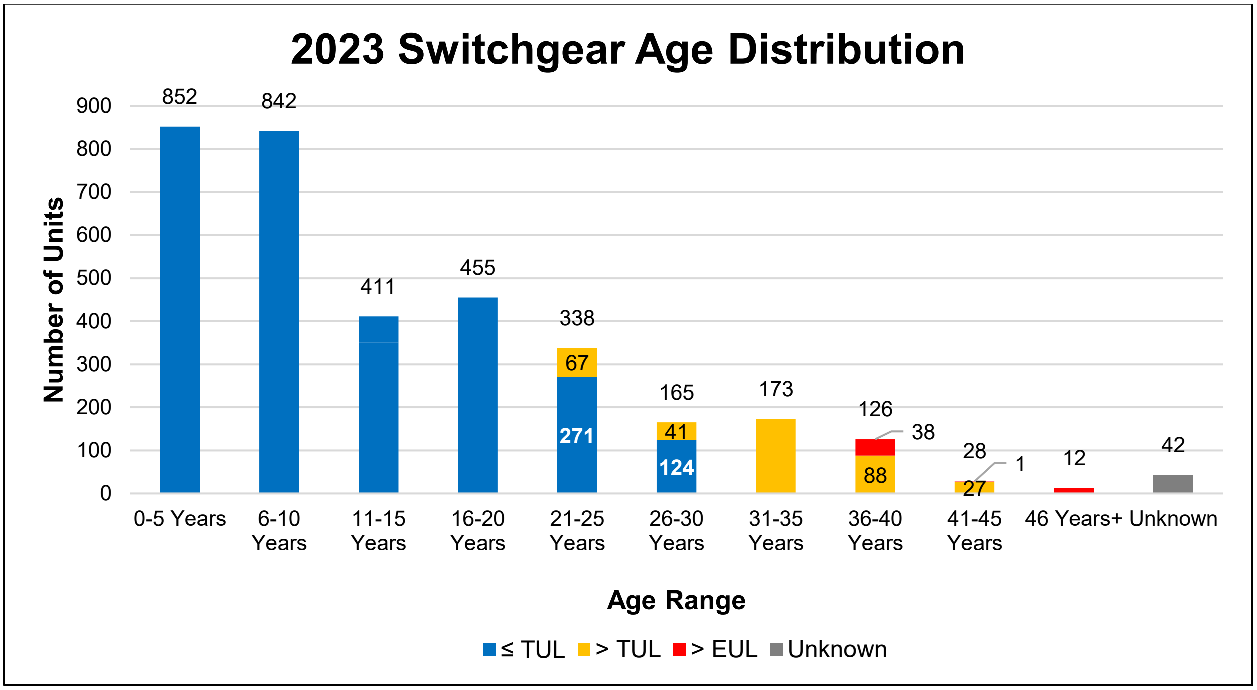

Figure 11 Pad-mounted switchgear Age Distribution for 2023

5.2.4 Health Index Formula and Results

Health Index of pad-mounted switchgear assesses the condition according to five components: Corrosion, Component Failure, Insulation, Oil Leak (for oil insulated switchgear), and Age. Presence and magnitude of oil leaks (for oil insulated switchgear), and structural corrosion are quantified during field inspections and are scored as a step score.

Age represents deterioration due to factors not captured by the other components of the model. The scoring method for age is described in *Section 3.1.2 Percentage Score*.

The Health Index for Air-type switchgear is computed by adding the weighted components of: Corrosion, Component Failure (such as signs of damage to mechanical springs, motors in motorized units, and fuse supports), Insulation, and Age, as indicated in Table 5.

Table 5 Pad-mounted Air Switchgear Health Index Parameters and Weights

#	Input	Input Weight (AIR)	Scoring Method
1	Corrosion	21%	Step Score
2	Component Failure	21%	Step Score
3	Insulation	43%	Step Score
4	Age	15%	Percentage Score

The Health Index for Solid Dielectric and SF_6 type switchgear is computed by adding the weighted components of Corrosion and Age, as indicated in Table 6.

Table 6 Pad-mounted, Solid Dielectric, SF_6 Switchgear Health Index Parameters & Weights

#	Input	Input Weight (SF_6, SD)	Scoring Method
1	Corrosion	85%	Step Score
2	Age	15%	Percentage Score

SF_6 leaks are not considered as a condition input. When an SF_6 leak is detected, the unit is repaired or replaced.

The Health Index for Oil type switchgear is computed by adding the weighted components of: Corrosion, Oil Leak, and Age, as indicated in Table 7.

Table 7 Pad-mounted Oil-type Switchgear Health Index Parameters and Weights

#	Input	Input Weight (OIL)	Scoring Method
1	Corrosion	42.5%	Step Score
2	Oil Leak	42.5%	Step Score
3	Age	15%	Percentage Score

Field Inspection Multiplier

If a pad-mounted switchgear exhibits significant degradation or imminent failure, as determined by field inspection, it is considered to be of Very Poor health and will have a maximum Health

Index of 25% (i.e., the Health Index is multiplied by 0.25). The physical conditions considered in this criterion are if any of inspection score less than 20%.

Accelerated Degradation Multiplier

Air-insulated switchgear are highly susceptible to flashover due to contamination from dust particles that breach the enclosure. Their continuous nominal operating voltage rating is 25 kV with a maximum operating rating of 29.2 kV. These units function relatively well when new; however, during their normal duty, they are exposed to multiple voltage stresses that reduce their insulating performance, particularly when installed on Ontario's 27.6 kV distribution system. The 25 kV nominal voltage rating has been an inherent flaw in the equipment since it was first introduced to the Ontario market. This lower nominal voltage contributes to the reduced life of the switchgear and reduces the ability of the switchgear to perform under abnormal conditions, leading to premature failures. This type of switchgear will have a maximum Health Index of 50% (i.e., the calculated score is multiplied by 0.5).

Figure 12 illustrates the Health Index distribution of pad-mounted switchgear, classified from Very Poor to Very Good. 329 pad-mounted switchgear are shown to be in the Very Poor or Poor category.

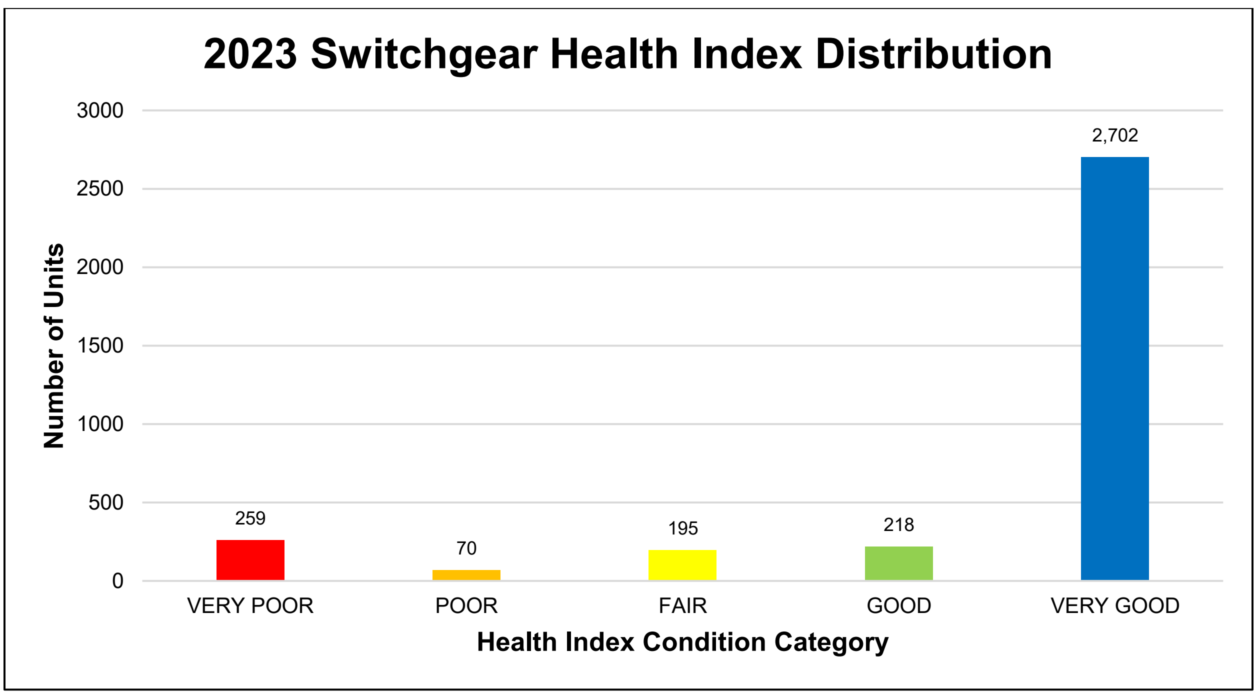

Figure 12 Pad-mounted Switchgear Health Index Distribution for 2023

Alectra proactively replaces deteriorated distribution switchgear to avoid public safety, environmental, and reliability risks. Failure to replace deteriorated switchgear can result in high-impact outages with large customer counts.

5.3 Overhead Switches

5.3.1 Summary of Asset Class

The primary function of overhead switches is to facilitate transfer of loads between feeders and to allow isolation of line sections or equipment for maintenance, safety, or other operating requirements. This class of switch is also known as a Load-Break Disconnect Switch (LBDS), or a Load Interrupting Switch (LIS), and can break load current.

5.3.2 Asset Degradation

The main degradation processes associated with switches include the following:

- Corrosion of steel hardware or operating rod
- Mechanical deterioration of linkages
- Switch blades falling out of alignment, which may result in excessive arcing during operation
- Loose connections
- Damaged insulators

The rate and severity of these degradation processes depend on several inter-related factors, including the operating duties and the environment in which the equipment is installed. In most cases, corrosion or rust represents a critical degradation process.

Consequences of overhead line switch failure may include customer interruption and safety concerns for operators.

5.3.3 Asset Class Demographics

Alectra's distribution system has 3,192 overhead switches. Figure 13 illustrates the age distribution of overhead switches. 183 overhead switches are shown to exceed the TUL of 40 years, of which 40 exceed the EUL of 55 years, representing 5.7% and 1.3%, respectively, of the total installed population.

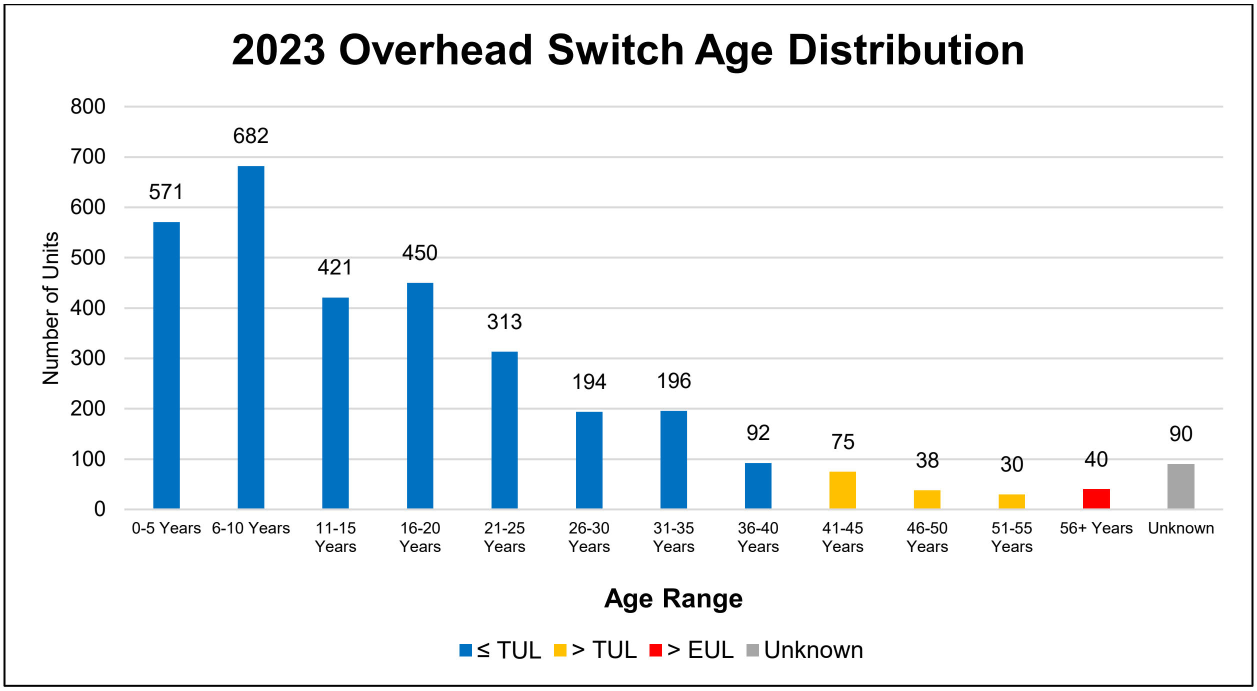

Figure 13 Overhead Switch Age Distribution for 2023

5.3.4 Health Index Formula and Results

Health index of overhead switches assesses the condition according to two components: Age and Field Inspection. Field inspection provides an overall assessment of condition. Age represents a proxy measure for switch deterioration over time. Field Inspection is assessed to determine the degree of degradation due to environmental and operational factors. Health Index is computed as a function of Age (i.e., percentage score) and Field Inspection (i.e., step score), as indicated in Table 8.

Table 8 Overhead Switch Health Index Parameters and Weights

#	Input	Input Weight	Scoring Method
1	Age	31%	Percentage Score
2	Field Inspection	69%	Step Score

Age represents deterioration due to factors not captured by the other components of the model. The scoring method for age is described in *Section 3.1.2 Percentage Score*.

Field Inspection Multiplier

If a pole-mounted load interrupting switch exhibits significant degradation or imminent failure, as determined by field inspection, it is considered to be of Very Poor health and will have a maximum Health Index of 25% (i.e., the calculated Health Index will be multiplied by 0.25). The physical condition considered in this criterion is if a major or moderate issue is identified.

Figure 14 illustrates the Health Index distribution of overhead switches, classified from Very Poor to Very Good. Eighty overhead switches are shown to be in the Very Poor or Poor category.

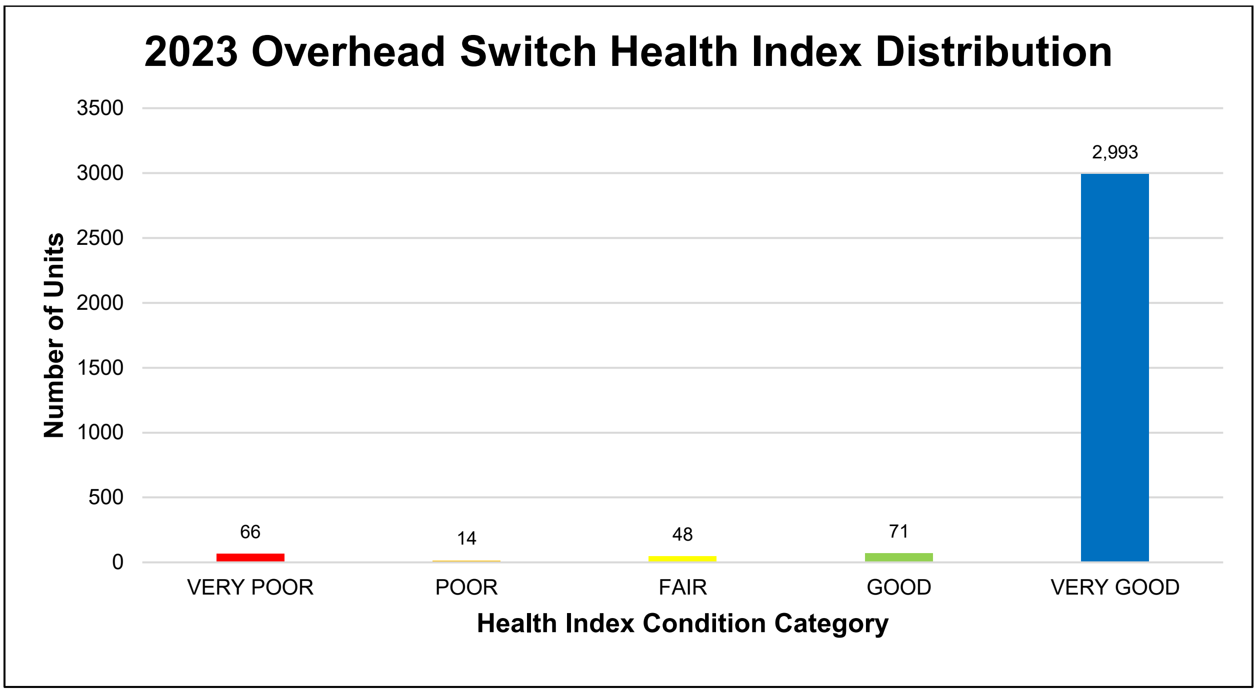

Figure 14 Overhead Switch Health Index Distribution for 2023

Alectra proactively replaces deteriorated overhead switches to avoid public safety and reliability risks. Failure to replace deteriorated overhead switches can result in high-impact outages with large customer counts.

5.4 Overhead Conductors

5.4.1 Summary of Asset Class

Electrical current flows through distribution line conductors, facilitating the movement of power throughout the distribution system. These conductors are supported by metal, wood, or concrete structures to which they are attached by insulator strings selected based on operating voltage. The conductors are sized for the amount of current to be carried, as well as other design requirements. Conductors hold mechanical tension in conjunction with electrical properties that facilitate flow of electricity.

5.4.2 Asset Degradation

The flow of electrical current causes the conductors' temperature to increase. As a result, the conductors expand. Fluctuations of current flow cause the conductors to expand and contract in a cyclical manner, which contributes to conductor deterioration over time. Mechanical processes, such as fatigue, creep, and corrosion, are accelerated by the expansion and contraction. The rate of degradation depends on several factors, including the size of conductor, metal/alloy component(s) of the conductor, type of conductor (e.g., solid or stranded), the variation in the flow of current, and ambient temperature.

Overloading conductors accelerates the deterioration process and can cause serious safety concerns, as well as excessive fault currents. Conductor failure is a safety hazard to the public and can cause significant power interruptions.

5.4.3 Asset Class Demographics

Alectra's distribution system has 18,463 km of overhead conductors with various sizes and ages. Figure 15 illustrates the age distribution of overhead conductors. 564 km of overhead conductor are shown to exceed the TUL of 60 years, of which 49 km exceed the EUL of 75 years, representing 3.1% and 0.3%, respectively, of the total installed population.

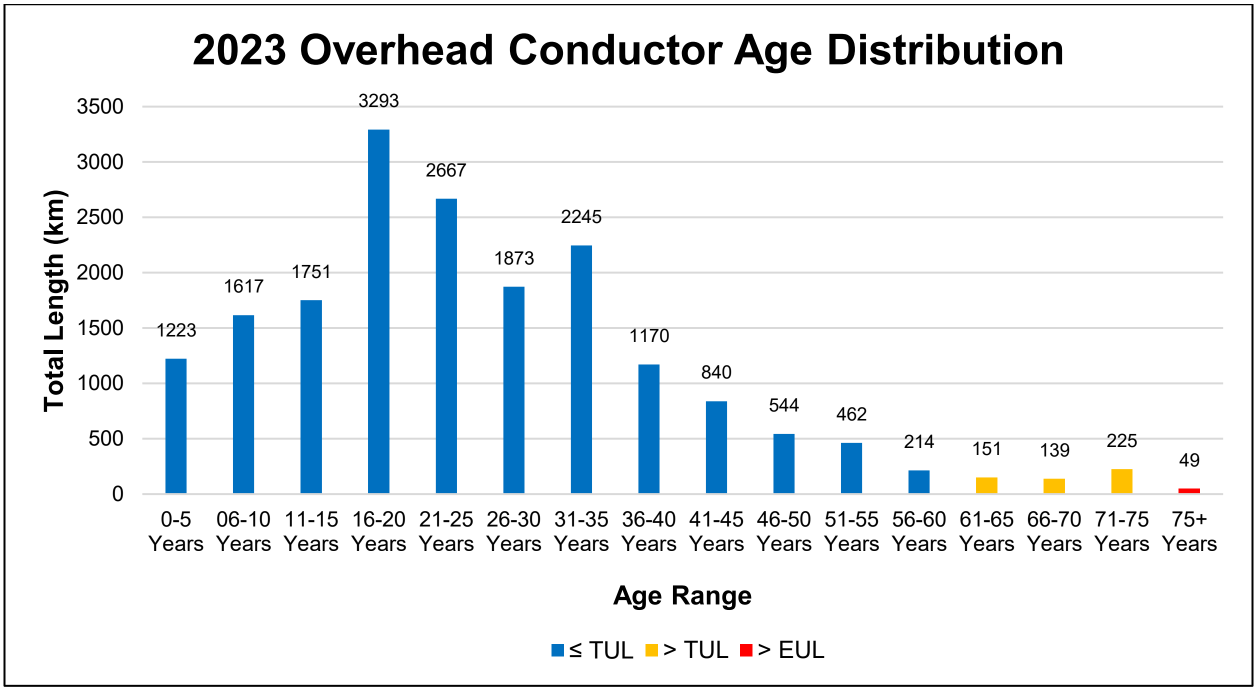

Figure 15 Overhead Conductor Age Distribution for 2023

5.4.4 Health Index Formula and Results

Health Index of overhead conductors assesses the condition based on Age (i.e., percentage score). Age represents a proxy measure for conductor deterioration over time due to environmental and operational factors. The scoring method for age is described in *Section 3.1.2 Percentage Score.*

Restricted Conductor Size Multiplier

Certain conductors are below the acceptable size for the safe and reliable operation of the system. Any conductor below AWG (American Wire Gauge) size #6 is considered restricted and undersized according to current utility practices. Such conductors represent a major safety risk and are considered to be of Very Poor Condition to reflect the importance of replacing the segment. This type of conductor will have a maximum Health Index of 25% (i.e., the calculated Health Index is multiplied by 0.25).

Figure 16 illustrates the Health Index distribution of overhead conductors, classified from Very Poor to Very Good. 443 km of overhead conductor are shown to be in the Very Poor or Poor category.

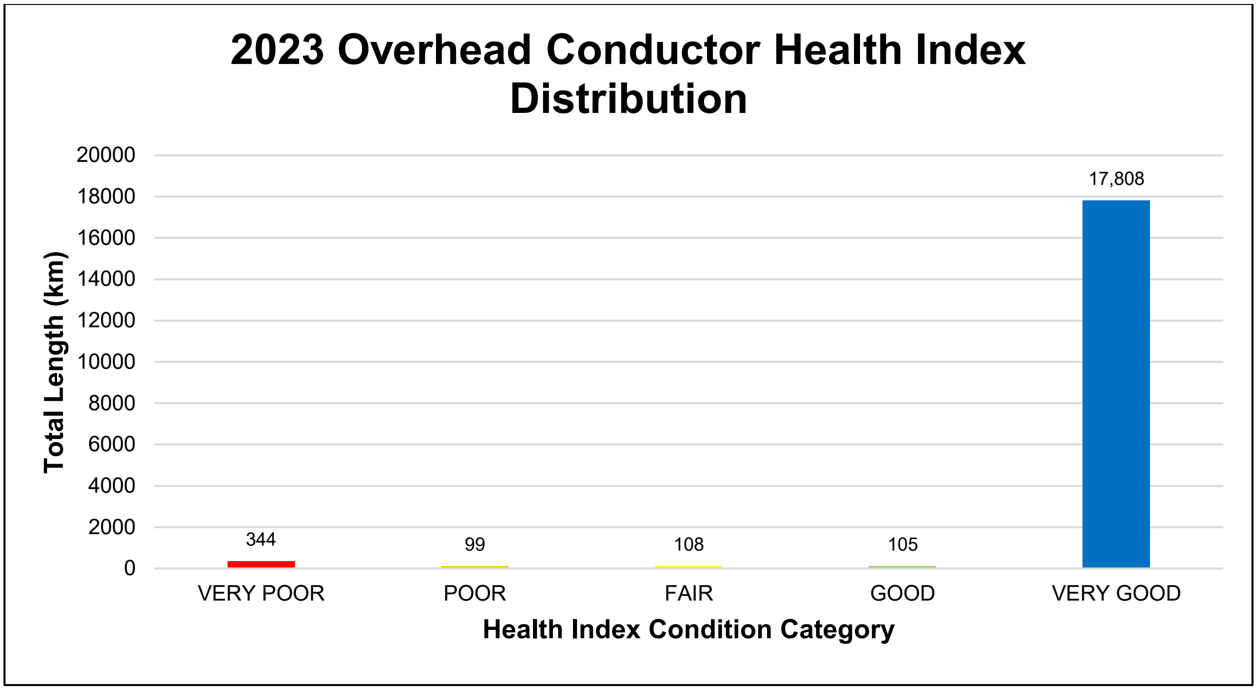

Figure 16 Overhead Conductor Health Index Distribution for 2023

Failure to replace deteriorated overhead conductors may lead to wire-down events, posing significant safety risks to the public. Undersized overhead conductors such as #6 copper have been identified as a public safety risk. Deteriorated and undersized overhead conductors are being replaced proactively.

5.5 Poles

Condition assessments are conducted for Alectra's wood and concrete poles.

5.5.1 Summary of Asset Class

Poles support overhead primary and secondary distribution lines. Any deterioration in structural strength of poles impacts the safe and reliable operation of the distribution system. Poles are a critical component of the distribution system and support many assets including conductors, transformers, switches, streetlights, telecommunication attachments, and other items, as well as providing physical separation between ground level and energized conductors. As a pole's physical condition and structural strength deteriorate, the pole may become inadequate for its intended function and should be replaced to maintain the integrity of the distribution system and to protect public safety. As poles deteriorate, they also become particularly susceptible to failure during storm and inclement weather events. A regular field inspection is conducted on poles to assess their condition.

5.5.2 Asset Degradation

Consequences of a pole failure can be serious. Poles with reduced strength present a significant risk to the public, Alectra employees, and contractors. Pole failures also have reliability impacts to the distribution system. The combination of severe weather, along with reduced strength, can lead to end-of-life failure scenarios where multiple poles lose their structural integrity and fail, possibly falling to the ground. Risk is mitigated through the regular inspection and field-testing to identify candidates for replacement prior to their failure. Wood poles and concrete poles have differing degradation processes.

5.5.2.1 Wood Poles

The wood species commonly used for distribution wood poles include Red Pine, Jack Pine, and Western Red Cedar (WRC). Since wood is a natural material, the degradation processes are different from those that affect other physical assets on electricity distribution systems. The degradation processes result in decay of the wood fibers, thus reducing the structural strength of the pole. The nature and severity of the degradation depends both on the type of wood, treatment preservatives, and the environment.

As a structural asset, assessing the condition of a wood pole is based on measuring the remaining structural strength and inspecting for signs of deterioration. Field inspection checks for indicators of decay, such as hollowing, pole top feathering, structural cracks, and other field indications of degradation. Pole residual strength is determined by conducting a resistograph test, where small probes are drilled through the pole to measure quantitatively the remaining structural strength of the wood fibers. This practise is scheduled with a 3-year cycle for wood poles greater than 15 years of age.

5.5.2.2 Concrete Poles

Concrete poles age in the same manner as any other concrete structures. Any moisture ingress inside the concrete poles results in freezing during the winter and damage to the concrete surface. Road salt spray can further accelerate the degradation process and lead to concrete spalling (i.e., piece of concrete flaking off the pole). Cracks develop over time from stretching or bending forces. These cracks propagate over time, resulting in structural cracks and spalling of the concrete.

Concrete poles contain metal rebar for reinforcement; water ingress and contaminants lead to corrosion of the rebar, thus reducing the structural integrity of the concrete pole. Rebar corrosion can lead to the accelerated deterioration, resulting in a reduced lifespan of a concrete pole.

5.5.3 Asset Class Demographics

5.5.3.1 Wood Poles

Alectra's distribution system has 105,262 wood poles. Figure 17 illustrates the age distribution of wood poles. 24,319 wood poles are shown to exceed the TUL of 45 years, of which 854 exceed the EUL of 75 years, representing 23.1% and 0.8%, respectively, of the total installed population.

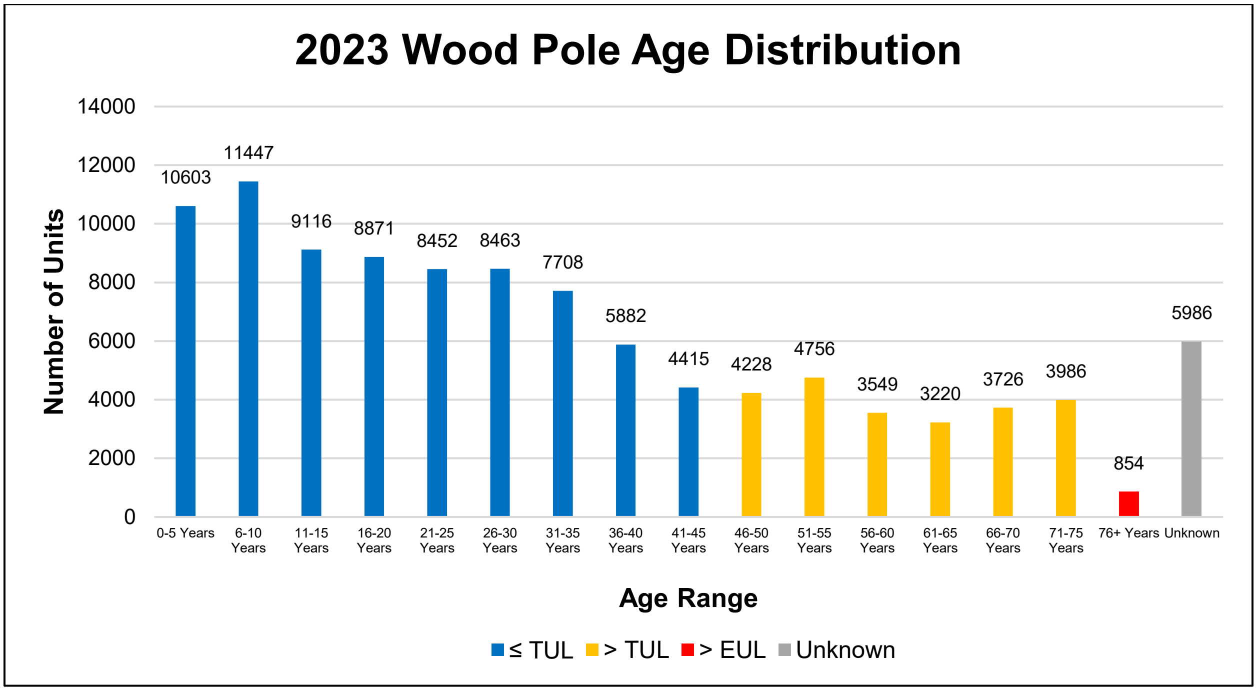

Figure 17 Wood Pole Age Distribution for 2023

5.5.3.2 *Concrete Poles*

Alectra's distribution system has 29,110 concrete poles. Figure 18 illustrates the age distribution of concrete poles. 1,699 concrete poles are shown to exceed the TUL of 60 years, of which 635 exceed the EUL of 80 years, representing 5.8% and 2.2%, respectively, of the total installed population.

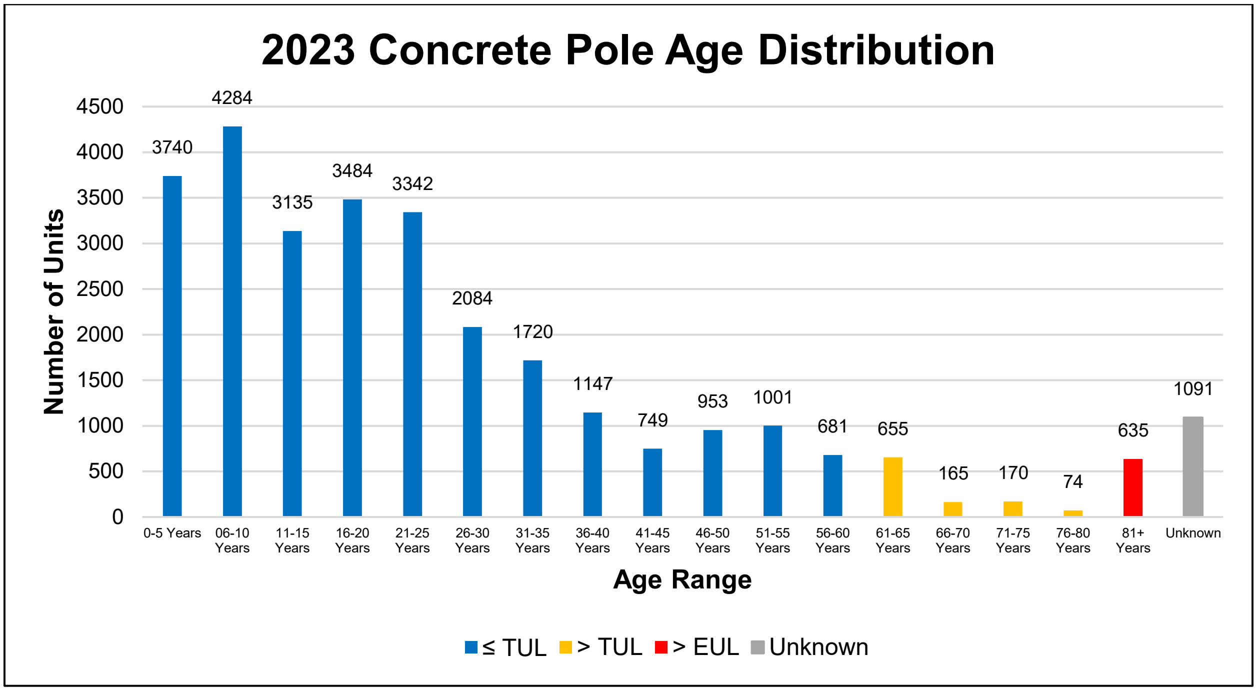

Figure 18 Concrete Pole Age Distribution for 2023

5.5.4 Health Index Formula and Results

Health Index condition parameters considered for wood poles and for concrete poles differ.

5.5.4.1 *Wood Poles*

Health Index of poles assesses the condition of the pole according to three components: Pole Remaining Strength, Overall Condition, and Age. Pole Remaining Strength is a vital component to the Health Index of wood poles and is determined by a specialized test. Remaining strength measurement is an evidence-based measurement of physical condition, and it is scored using percentage scoring.

Overall Condition is captured during the field inspection cycle of the wood poles and includes, but is not limited to, signs of decay, damage, infestation and bends/leans. Overall Condition of a wood pole is scored using step scoring.

Age represents deterioration due to other factors not captured by the other components of the model. The scoring method for age is described in *Section 3.1.2 Percentage Score*.

The Health Index for wood poles is computed by adding the weighted inputs of Pole Remaining Strength, Overall Condition, and Age, as indicated in Table 9.

Table 9 Wood Pole Health Index Parameters and Weights

#	Input	Input Weight	Scoring Method
1	Pole Strength Test	49%	Percentage Score
2	Overall Condition (Field Inspection)	36%	Step Score
3	Age	15%	Percentage Score

Pole Remaining Strength Multiplier

The Canadian Safety Association (CSA) defines the standards for overhead distribution system construction and the use of wood poles. Among other factors, Alectra is guided in its pole assessment process by Clause 8.3.1.3 of CSA Standard C22.3 No. 1-10, which states that:

> *"When the strength of a structure has deteriorated to 60% of the required capacity, the structure shall be reinforced or replaced."*

If a wood pole is measured to have 60% or less in remaining strength, it is considered to be of Very Poor health and will have a maximum Health Index of 25% (i.e., the Health Index is multiplied by 0.25).

Field Inspection Multiplier

If a wood pole exhibits any major degradation or imminent failure, as determined by field inspection, it is considered to be of Very Poor health and will have a maximum Health Index of 25% (i.e., the Health Index is multiplied by 0.25). The physical conditions considered in this criterion are major damage, decay, splitting, insect infestation, bending and leaning.

Figure 19 illustrates the Health Index distribution of wood poles, classified from Very Poor to Very Good. 9,691 wood poles are shown to be in the Very Poor or Poor category.

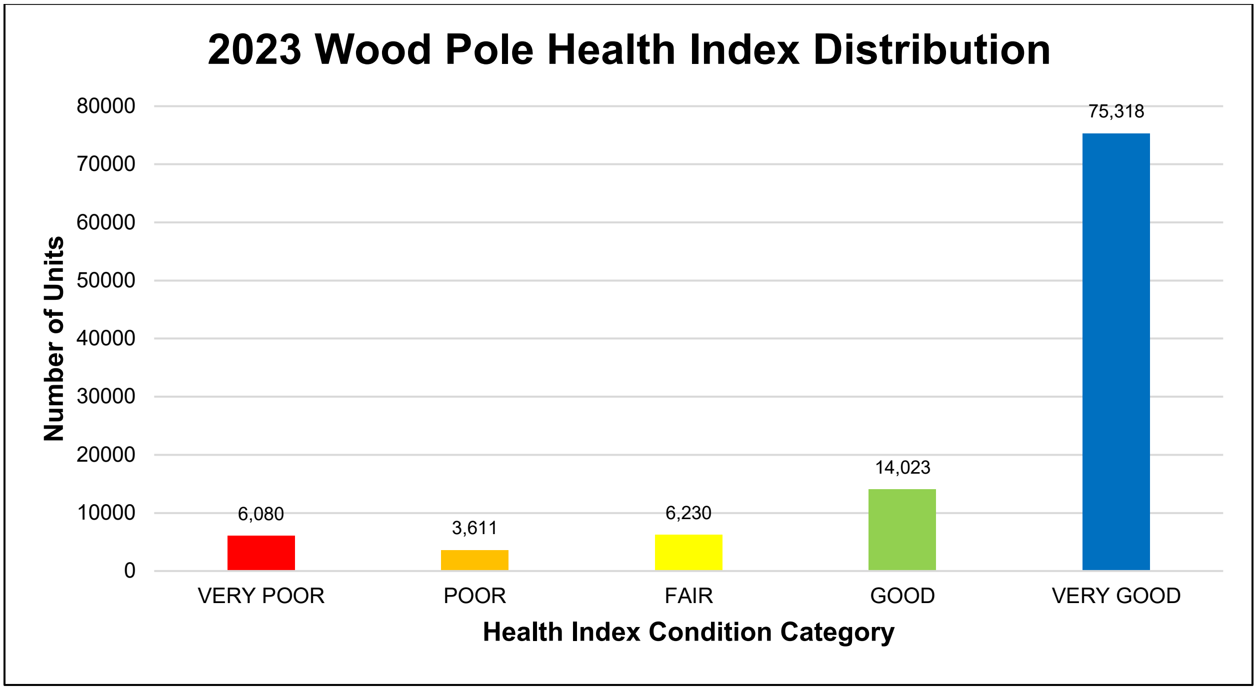

Figure 19 Wood Pole Health Index Distribution for 2023

Alectra has identified growth in the number of deteriorated wood poles, increasing the risk of pole failure and susceptibility to severe weather events. Pole failures are a safety risk to the public and can lead to high-impact outages. The ACA model does not factor in poles that could be severely undersized according to current CSA standards.

5.5.4.2 Concrete Poles

Health Index of concrete poles assesses the condition of the pole according to two inputs: Overall Condition and Age.

Overall Condition is captured during the field inspection cycle of the concrete poles and includes, but is not limited to, signs of mechanical damage and cracks. Age represents deterioration due to factors not captured by the other inputs of the model. The scoring method for age is described in *Section 3.1.2 Percentage Score.*

The Health Index is computed by adding the weighted inputs of Overall Condition from field inspection and Age, as indicated in Table 10.

Table 10 Concrete Pole Health Index Parameters and Weights

#	Input	Input Weight	Scoring Method
1	Overall Condition (Field Inspection)	69%	Step Score
2	Age	31%	Percentage Score

Field Inspection Multiplier

If a concrete pole exhibits significant degradation or imminent failure, as determined by field inspection, it is considered to be of Very Poor health and will have a maximum Health Index of 25% (i.e., the calculated Health Index is multiplied by 0.25). The physical conditions considered in this criterion are major cracks.

Figure 20 illustrates the Health Index distribution of concrete poles, classified from Very Poor to Very Good. 586 concrete poles are shown to be in the Very Poor or Poor category.

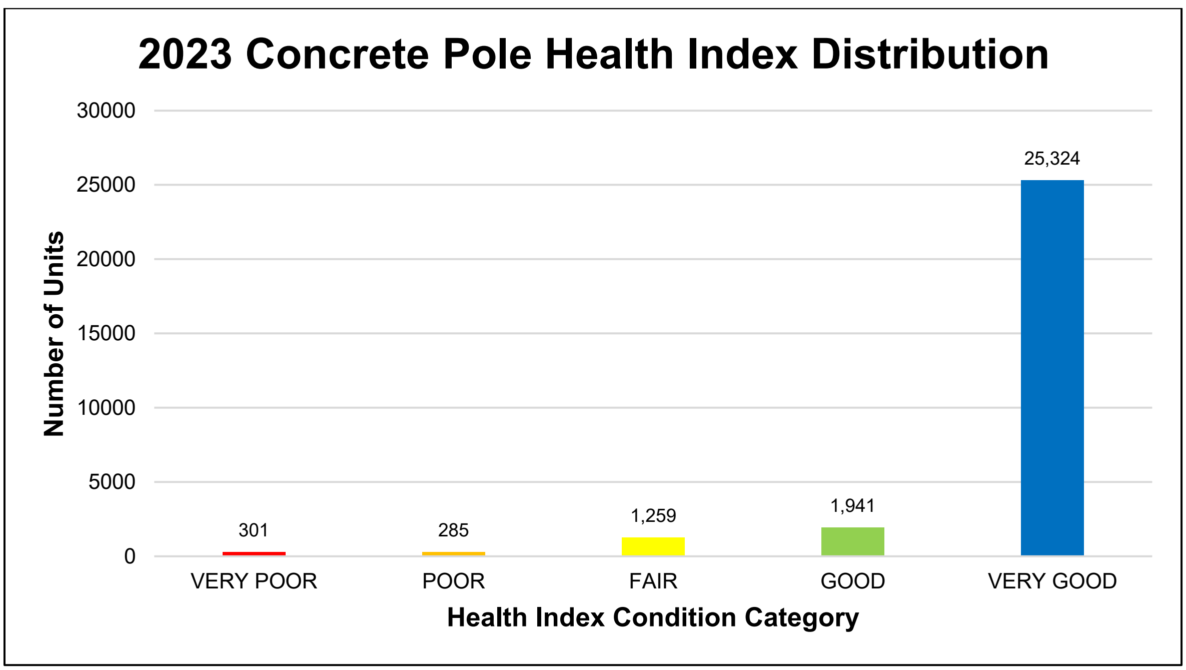

Figure 20 Concrete Pole Health Index Distribution for 2023

Alectra has identified an increase in the number of deteriorated concrete poles, increasing the risk of a pole failure. Deteriorated poles are highly susceptible to severe weather events, posing a risk to public safety and high-impact outages.

5.6 Underground Primary Cables

Primary underground cables are critical to the delivery of electrical service across Alectra Utilities' service territory. Underground distribution cables are commonly utilized in urban areas, where it is beneficial over overhead infrastructure for increased reliability and safety considerations.

5.6.1 Summary of Asset Class

The asset categories of distribution system underground cables include underground cross-link-polyethylene (XLPE) cables, paper insulated lead covered (PILC) cables, and ethylene-propylene rubber (EPR) cables, all at voltage levels of 44 kV or below. Included are direct-buried and installed-in-duct feeder cables, underground cable sections running from stations to overhead lines and from overhead lines to customer stations and switches.

5.6.2 Asset Degradation

Faults on primary underground cables are typically caused by insulation failure within a localized area.

5.6.2.1 Cross-Linked Polyethylene (XLPE) Cables

Polymeric insulation is very sensitive to discharge activity. It is therefore very important that the cable, joints, and accessories are discharge-free when installed. Older-vintage cables are susceptible to moisture ingress (i.e., water treeing), especially if installed direct buried, or with terminations and splices susceptible to insulation breakdown.

Moisture ingress can result in localized failures, especially for direct buried cables, or cable with terminations and splices susceptible to insulation breakdown. Manufacturing improvements and development of tree-retardant XLPE cables have reduced the rate of deterioration and insulation breakdown from water treeing.

5.6.2.2 Paper Insulated Lead Covered (PILC) Cables

For PILC cables, the two significant long-term degradation processes are corrosion of the lead sheath, and dielectric degradation of the oil-impregnated paper insulation. Isolated sites of corrosion resulting in moisture penetration or isolated sites of dielectric deterioration resulting in insulation breakdown can result in localized failures. However, if either of these conditions becomes widespread, there will be frequent cable failures, and the cable can be deemed to be at end-of-life.

5.6.2.3 Ethylene-Propylene Rubber (EPR) Cables

For EPR cables, long term degradation can occur due to mechanical damage, overheating, or the impact of moisture ingress and chemical deterioration.

5.6.3 Asset Class Demographics

5.6.3.1 Cross-Linked Polyethylene (XLPE) Cables

Alectra's distribution system has 23,106 km of primary underground XLPE cable. XLPE cables are categorized by type, as described below. Each type has a different expected useful life, based on industry averages and Alectra's experience.

- **Non-Tree-Retardant cables (NON-TR)**:
  Vintage 1988 or older; TUL 30 years; EUL 40 years
- **Tree-Retardant Direct-Buried cables (TR-DB)**:
  Vintage 1989-1993; TUL 35 years; EUL 45 years
- **Tree-Retardant or Strand-Blocked In-Duct cables (TR-ID):**
  Vintage 1994 or newer; TUL 40 years; EUL 55 years

Figure 21 illustrates the age distribution of XLPE cables. 6,650.9 km of all XLPE cable are known to exceed the TUL, of which 2,374.6 km exceed the EUL, representing 28.8% and 10.3%, respectively, of the total installed population. The majority of these aging cables are non-tree-retardant type.

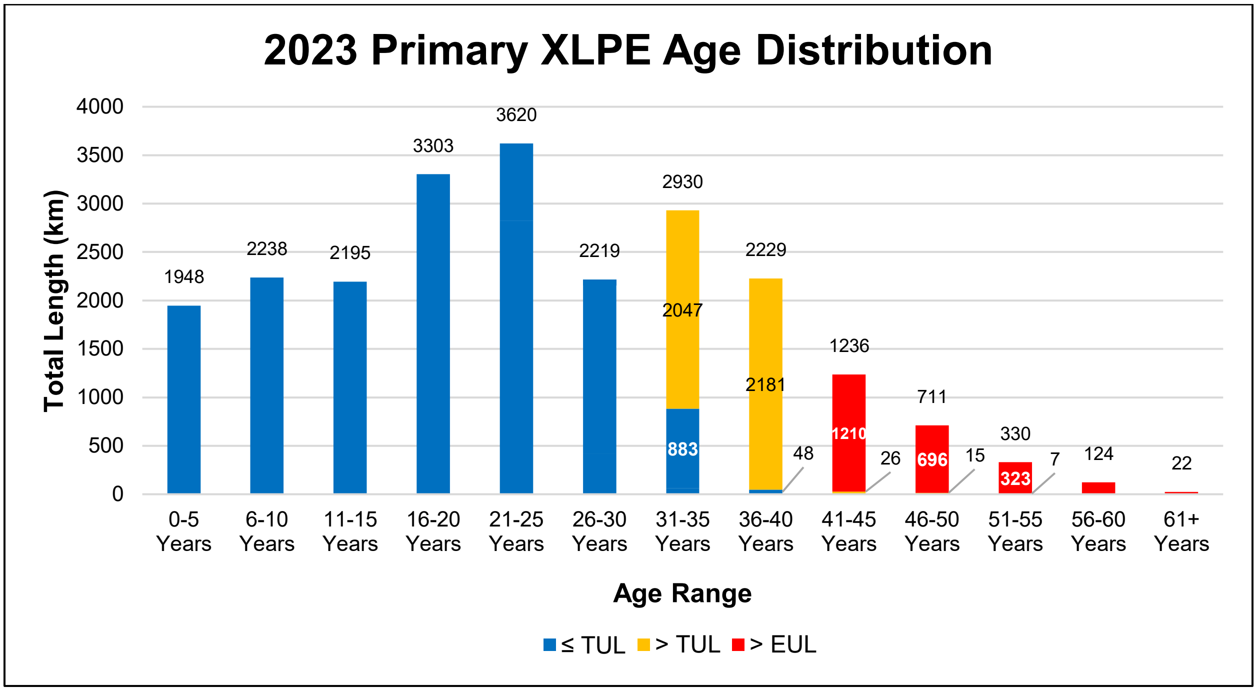

Figure 21 Primary XLPE Cable Age Distribution for 2023

5.6.3.2 Paper Insulated Lead Covered (PILC) Cables

Alectra's distribution system has 474 km of primary underground PILC cable. Figure 22 illustrates the age distribution of PILC cables. 56 km of PILC cable are shown to exceed the TUL of 60 years, of which 11 km exceed the EUL of 70 years, representing 11.8% and 2.3%, respectively, of the total installed population.

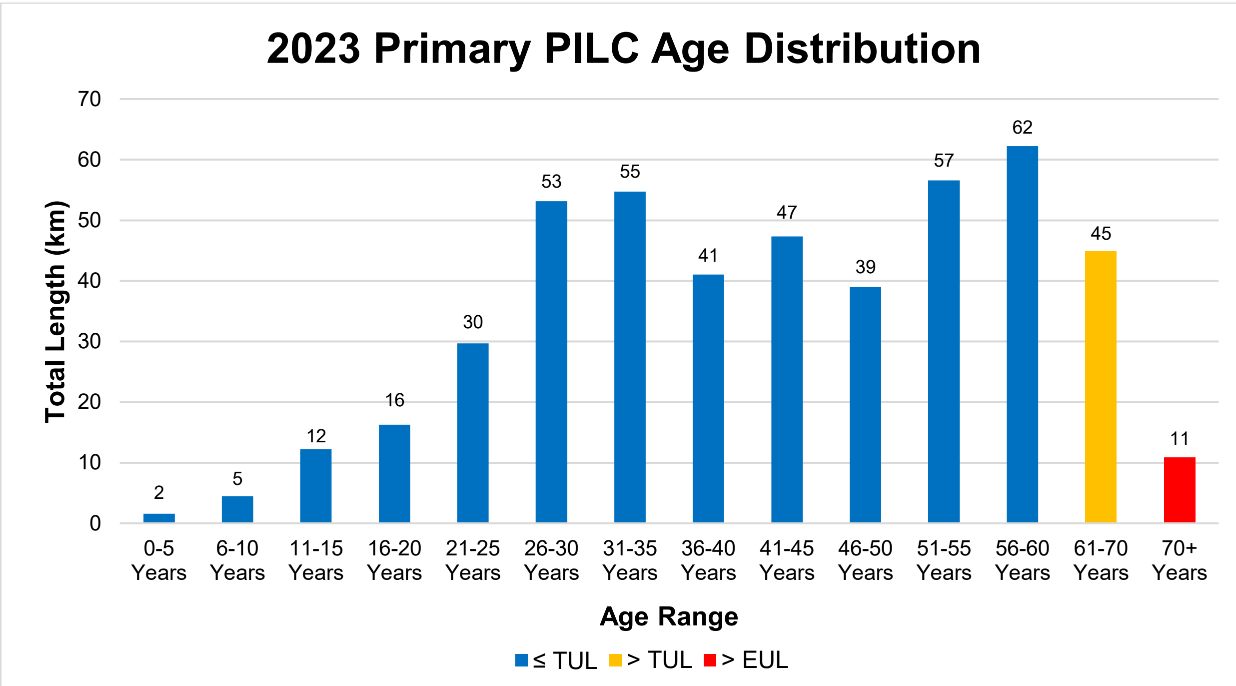

Figure 22 Primary PILC Cable Age Distribution for 2023

5.6.3.3 Ethylene-Propylene Rubber (EPR) Cables

Alectra's distribution system has about 114 km of primary underground EPR cable. EPR cables have a TUL of 25 years and an EUL of 45 years. Figure 23 illustrates the age distribution of EPR cables. Alectra's population of EPR cables is relatively new, with none exceeding 15 years in age. No EPR cable exceeds the TUL.

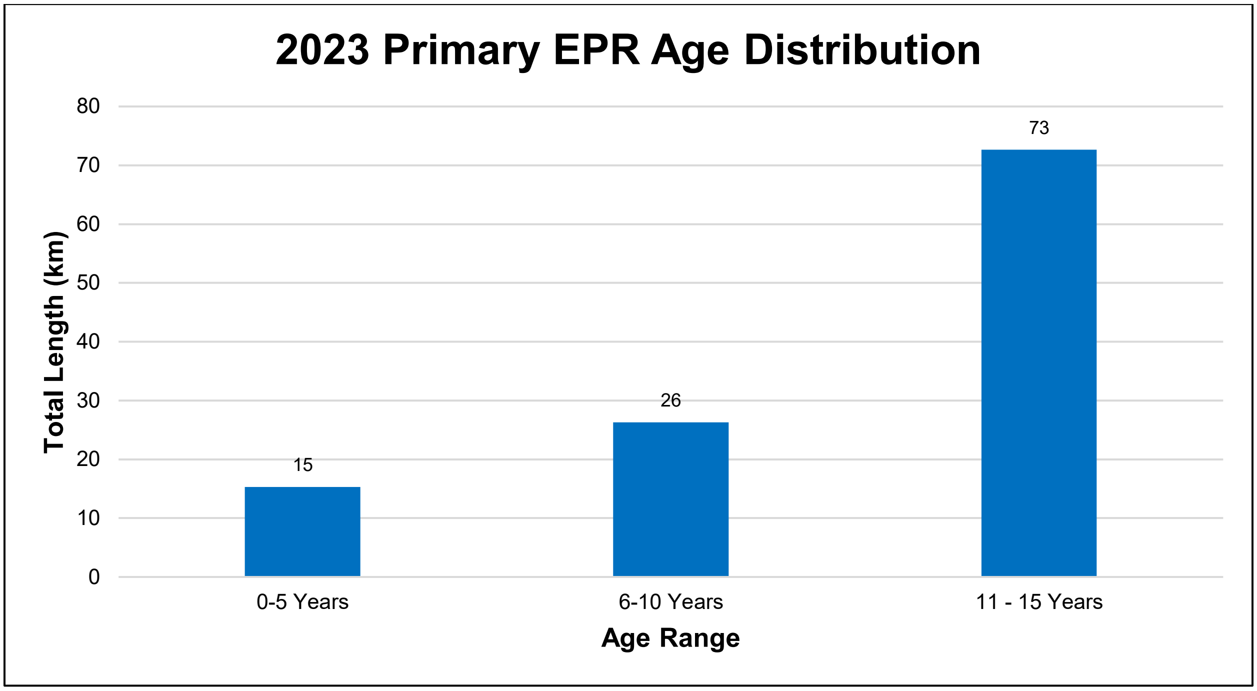

Figure 23 Primary EPR Cable Age Distribution for 2023

5.6.4 Health Index Formula and Results

For all cable types, Health Index is computed as a function of Age (i.e., percentage score). The scoring method for age is described in *Section 3.1.2 Percentage Score.*

5.6.4.1 Cross-Linked Polyethylene (XLPE) Cables

Scoring curves for the three types of XLPE cable differ, as illustrated in Figure 24.

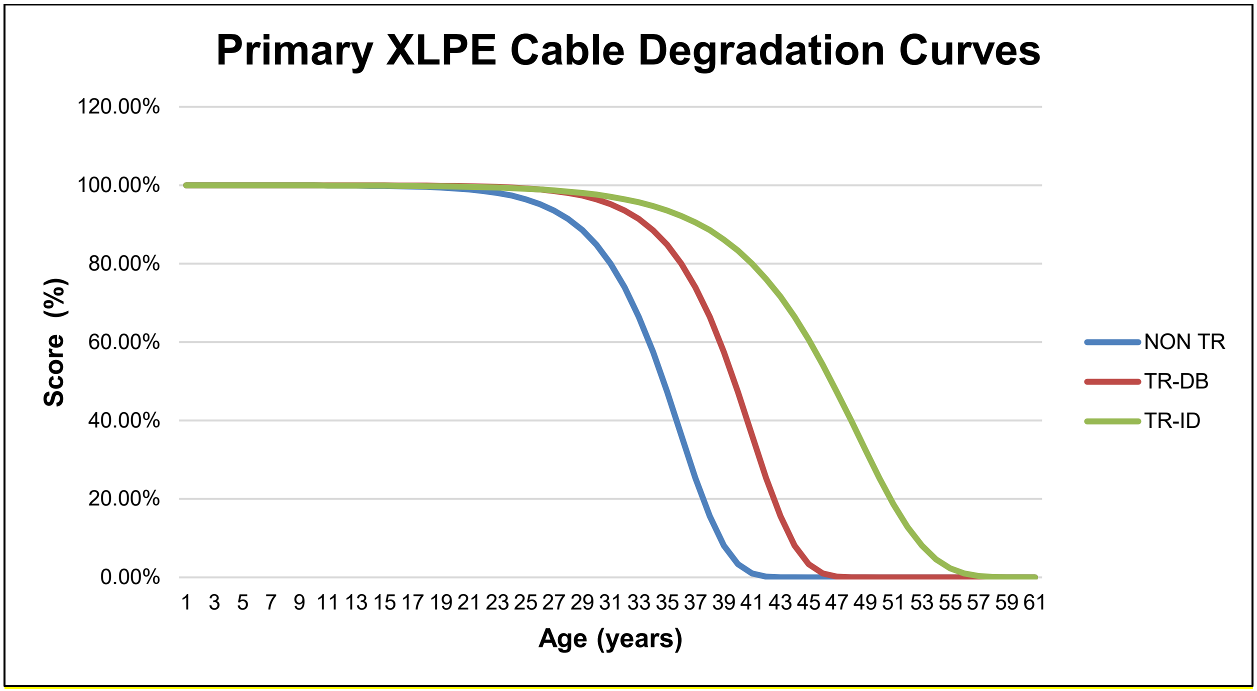

Figure 24 Primary XLPE Cable Health Index as a Function of Age

Figure 25 illustrates the Health Index distribution of primary XLPE cables, classified from Very Poor to Very Good. 5,114 km of XLPE cable are shown to be in the Very Poor or Poor category.

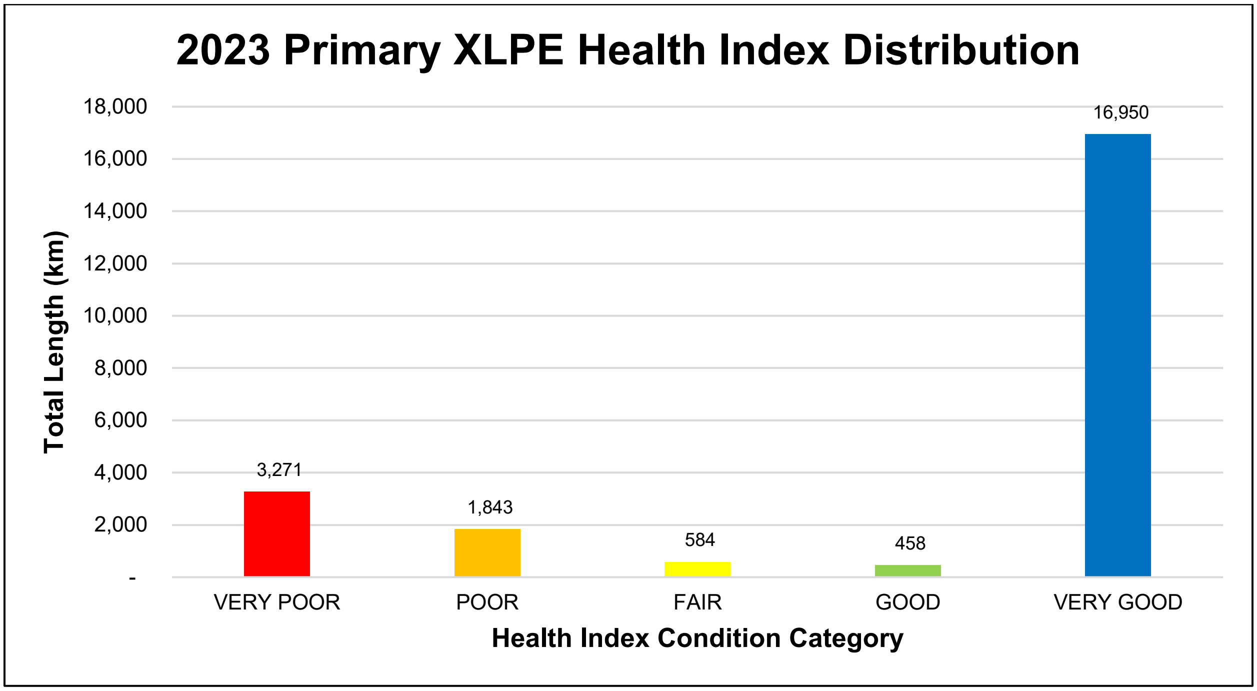

Figure 25 Primary XLPE Cable Health Index Distribution for 2023

Alectra's population of deteriorated XLPE primary cable has increased significantly. Failure to replace deteriorated XLPE primary cable will lead to declining reliability, frequent outages, and increasing operational costs. Going forward, an increase in investment pacing is required to address customer concerns.

5.6.4.2 Paper Insulated Lead Covered (PILC) Cables

Figure 26 illustrates the Health Index distribution of primary PILC cables, classified from Very Poor to Very Good. 39 km of PILC cable are shown to be in the Very Poor or Poor category.

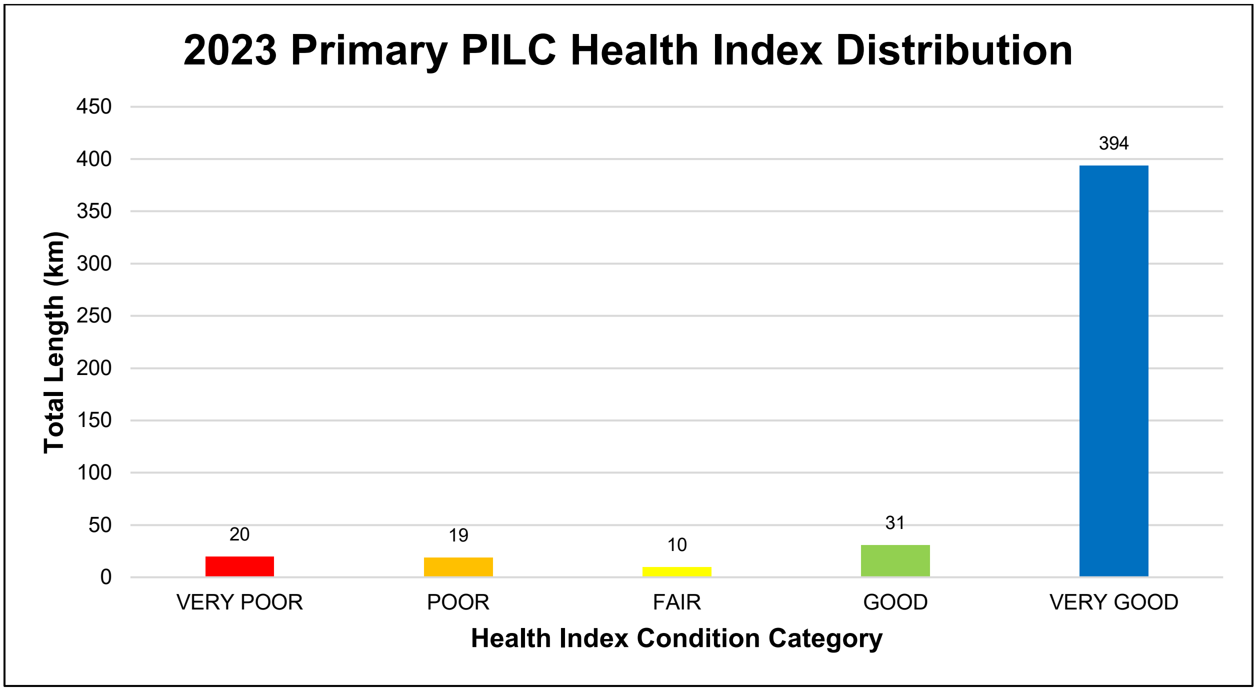

Figure 26 Primary PILC Cable Health Index Distribution for 2023

5.6.4.3 Ethylene-Propylene Rubber (EPR) Cables

Figure 27 illustrates the Health Index distribution of EPR cables, classified from Very Poor to Very Good. No EPR cable is in the Very Poor or Poor category.

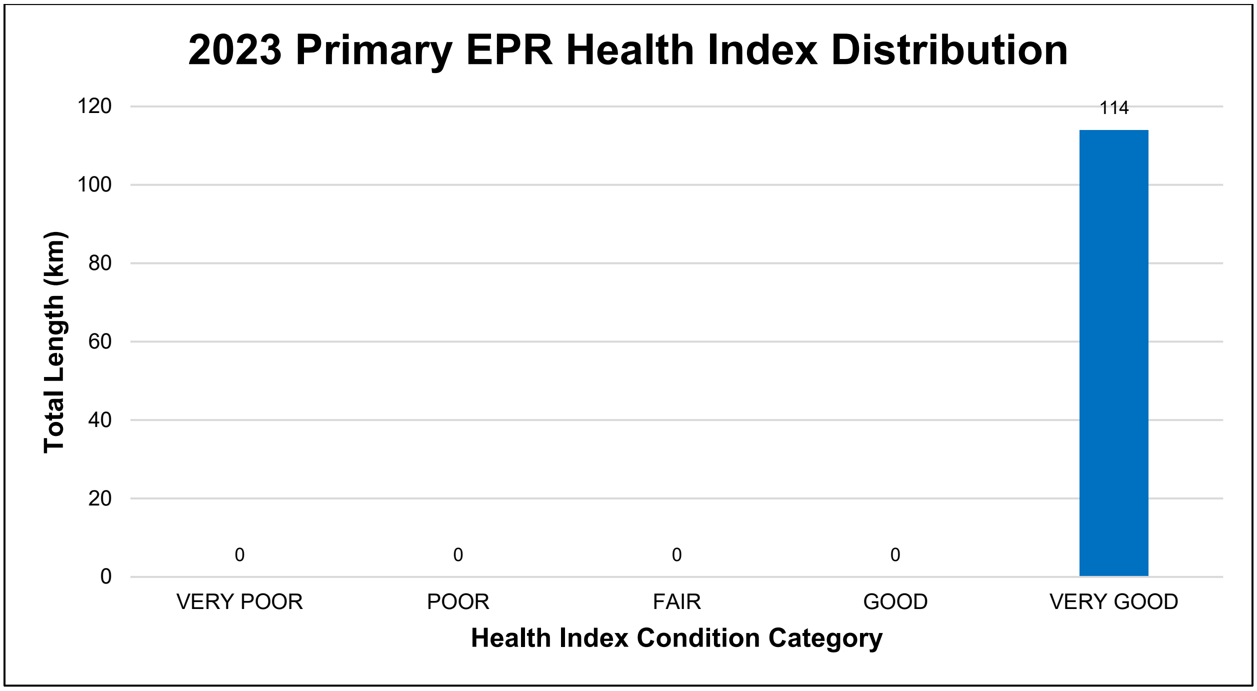

Figure 27 Primary EPR Cable Health Index Distribution for 2023

6 Station Assets

The Alectra distribution system includes two classes of stations, transformer stations (TS) and municipal stations (MS) or substations. Alectra transformer stations are supplied from Hydro One's high-voltage transmission grid at 115 kV or 230 kV. Alectra municipal stations are supplied from the medium-voltage distribution system at 44 kV, 27.6 kV, or 13.8 kV from transformer stations. Alectra's system has 14 transformer stations, and 149 municipal stations, all owned and operated by Alectra.

Stations may consist of many types of components and subcomponents. Station assets considered in this report are the following:

- Station power transformers
- Station circuit breakers
- Station class switchgear

6.1 Power Transformers

6.1.1 Summary of Asset Class

Station power transformers are used to step down transmission or sub-transmission voltage to distribution voltage. The two general classifications of station power transformers are transmission station (TS) transformers and municipal station (MS) transformers. TS transformers are supplied from the high-voltage transmission grid at either 230 kV or 115 kV and step voltage down to 44 kV, 27.6 kV, or 13.8 kV. MS transformers are supplied from the medium-voltage distribution system at 44 kV, 27.6 kV, or 13.8 kV, and step voltage down to 27.6 kV, 13.8 kV, 8.32 kV, or 4.16 kV. TS transformers owned and operated by Alectra have fully-cooled ratings of 50 MVA, 83.3 MVA, and 125 MVA, and MS transformer ratings typically have base Oil Natural Air Natural (ONAN) ratings ranging from 3 MVA to 22 MVA.

Power transformers employ many different design configurations, but they are typically made up of the following main components: Primary and secondary windings, Laminated iron core, Internal insulating mediums, Main tank, Bushings, Cooling system (including radiators, fans and pumps, where applicable), Off-load tap changer (Optional), On-load tap changer (Optional), Instrument transformers, Control mechanism cabinets, and Instruments and gauges.

Transformer primary and secondary windings are installed on a laminated iron core. In most power transformers, mineral oil serves as the insulating medium, providing insulation of the energized coils, as well as the coolant. Some power transformers use a natural ester oil, such as FR3[2], as the insulating medium. The transformer coil insulation is reinforced with different forms of solid insulation that include wood-based paperboard (pressboard), wrapped paper, and insulating tapes. The transformer main tank holds the active components of the transformer submersed in oil and maintains a sealed environment through the normal variations of temperature and pressure. Typically, the main tank is designed to withstand a full vacuum for initial and subsequent oil fillings and can sustain a positive pressure. The main tank also supports the internal and external components of the transformers. Bushings are used to facilitate the egress of conductors to connect ends of the coils to a power supply system in an insulated, sealed (oil-tight and weather-tight) manner.

The purpose of a cooling system in a power transformer is to efficiently dissipate heat generated due to copper and iron losses and to help maintain the windings and insulation temperature within an acceptable range. Multiple cooling stages allow for increases in load carrying capability. Loss of any stage or cooling element may result in a forced de-rating of the transformer. Transformer cooling system ratings are typically expressed as one of the following:

- Self-cooled (radiators) with designation as ONAN (oil natural, air natural)
- Forced cooling first stage (fans) with designation as ONAF (oil natural, air forced)
- Forced cooling second stage (fans and pumps) with designation as OFAF (oil forced, air forced)

From the view of both financial and operational risk, power transformers are the most important asset installed on the distribution and transmission systems.

6.1.2 Asset Degradation

For most transformers, end of life is typically established as the failure of the insulation system and, more specifically, the failure of pressboard and paper insulation. While the insulating oil can be treated or changed, it is not practical to change the paper and pressboard insulation. The condition and degradation of the insulating oil, however, plays a significant role in aging and deterioration of a transformer, as it directly influences the speed of degradation of the paper insulation. The degradation of oil and paper in transformers is essentially an oxidation process. The three important factors that impact the rate of oxidation of oil and paper insulation are presence of oxygen, high temperature, and moisture.

[2] FR3 is a trademarked brand of natural ester dielectric fluid produced by Cargill Inc

Transformer oil is made up of complex hydrocarbon compounds, containing anti-oxidation compounds. Despite the presence of oxidation inhibitors, oxidation occurs slowly under normal operating conditions. The rate of oxidation is a function of internal operating temperature and age. The oxidation rate increases as the oil ages, reflecting both the depletion of the oxidation inhibitors and the catalytic effect of the oxidation products on the oxidation reactions. The products of oxidation of hydrocarbons are moisture, which causes further deterioration of the insulation system, and organic acids, which result in formation of solids in the form of sludge. Increasing acidity and water levels result in the oil being more aggressive to the paper, hence accelerating the ageing of the paper insulation. Formation of sludge adversely impacts the cooling capability of the transformer and adversely impacts its dielectric strength. An indication of the condition of insulating oil can be obtained through measurements of its acidity, moisture content, and breakdown strength.

The paper insulation consists of long cellulose chains. As the paper ages through oxidization, these chains are broken. The tensile strength and ductility of insulting paper are determined by the average length of the cellulose chains; therefore, as the paper oxidizes, the tensile strength and ductility are significantly reduced, and insulating paper becomes brittle. In addition to the general oxidation of the paper, degradation and failure can also result from partial discharge (PD). PD can be initiated if the level of moisture is allowed to develop in the paper, or if there are other minor defects, within active areas of the transformer.

The relative levels of carbon dioxide and carbon monoxide dissolved in oil can provide an indication of paper degradation. Detection and measurement of furans in the oil provides a more direct measure of the paper degradation. Furans are a group of chemicals that are created as a by-product of the oxidation process of the cellulose chains. The occurrence of partial discharge and other electrical and thermal faults in the transformer can be detected and monitored by measurement of hydrocarbon gases in the oil through Dissolved Gas Analysis (DGA).

6.1.3 Asset Class Demographics

Alectra’s distribution system has 289 power transformers, including 27 spare units. These are comprised of 31 TS transformers, three of which are spares, and 258 MS transformers, which include 24 spares and units undergoing refurbishment. Figure 28 illustrates the age distribution of power transformers. 49 transformers are shown to exceed the TUL of 45 years, of which four exceed the EUL of 60 years, representing 17% and 1.4%, respectively, of the total population. All 49 transformers exceeding TUL are at municipal stations.

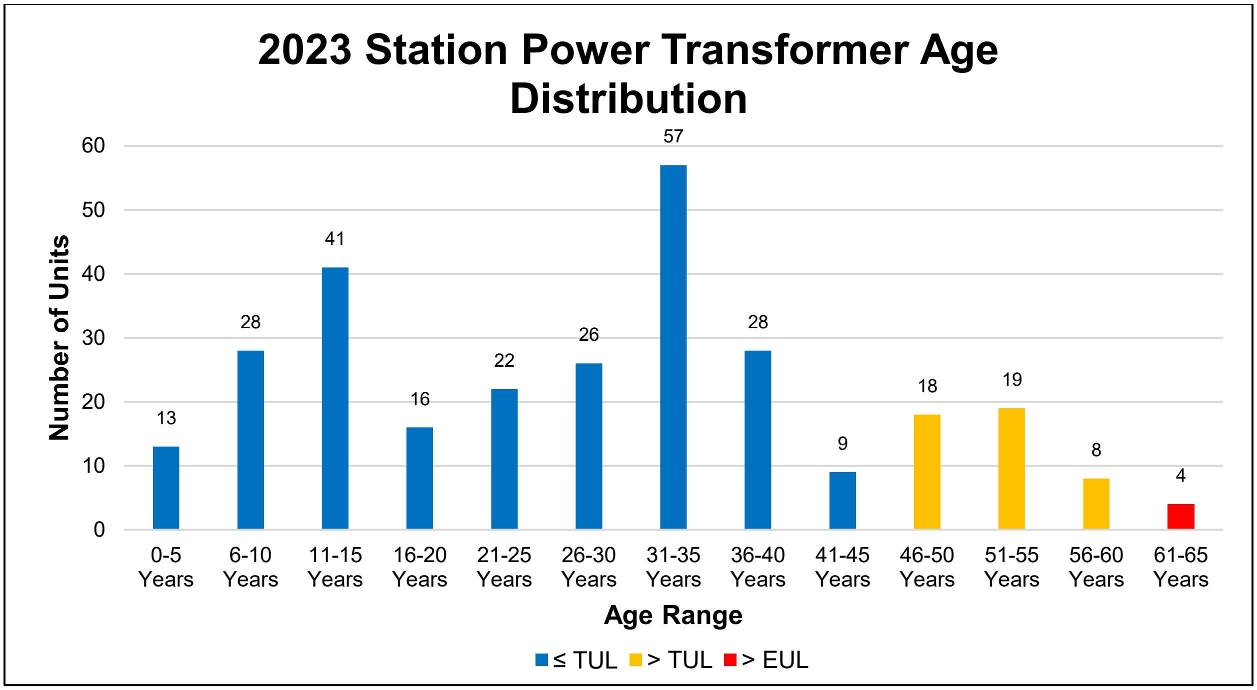

Figure 28 Station Power Transformer Age Distribution for 2023

6.1.4 Health Index Formula and Results

Health index of power transformers assesses the condition of the transformer according to four main components: Insulation, Cooling, Sealing and Connection, and Service Record. Insulation is the primary condition indicator and contributes to 70% of the Health Index. Included in insulation condition are oil quality analysis, oil dissolved gas analysis (DGA), and winding Doble and furan test results. Transformer loading is also considered under Service Record. Sufficient condition information without age is now available for all power transformers.

The Health Index is computed by adding the weighted components of overall condition, as indicated in Table 11.

Table 11 Power Transformer Health Index Parameters and Weights

#	Input	Input Weight
1	Insulation	70%
2	Cooling	7.50%
3	Sealing and Connection	7.50%
4	Service Record	15%

Most of the input for the condition parameters within the insulation category is provided by third-party vendors who perform oil analysis of samples extracted from the transformers. Scores for the remainder of the Condition Parameters are gathered through surveys that are completed by Subject Matter Experts in each operating area. Service record includes loading history.

DGA Multiplier

If a power transformer's oil sample results indicate a low overall oil DGA score, as defined by scoring criteria, will have a maximum Health Index of 50% (i.e., the calculated score is multiplied by 0.5). A low DGA score will warrant investigation.

Explosive Gas Multiplier

A high concentration of acetylene in a power transformer's oil sample results indicates that there is a potential for an explosive failure and imminent intervention is required. A transformer with a high concentration of acetylene, as defined by scoring criteria, is considered to be in Very Poor condition, will be considered as a potential candidate for replacement, and will have a maximum Health Index of 10% (i.e., the calculated Health Index is multiplied by 0.1).

Where both multipliers (Explosive Gas and DGA) are triggered, the lower of the two applies (i.e., the Explosive Gas Multiplier).

Figure 29 illustrates the Health Index distribution of power transformers, classified from Very Poor to Very Good. Twelve power transformers are shown to be in the Very Poor or Poor category.

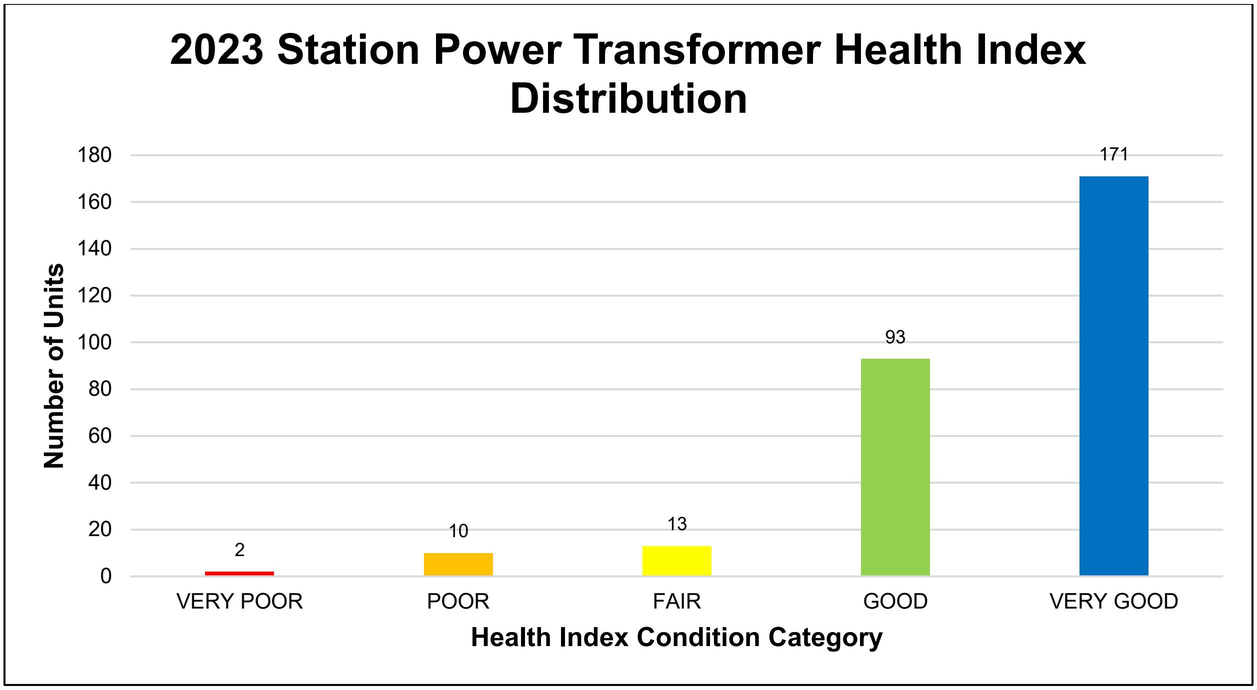

Figure 29 Station Power Transformer Health Index Distribution for 2023

Alectra has managed deteriorating power transformers through a combination of online monitoring and enhanced maintenance practices.

6.2 Circuit Breakers

6.2.1 Summary of Asset Class

Circuit breakers are used to sectionalize and isolate circuits or other assets. They are often categorized by the insulation medium used in the circuit breaker and by the fault current interruption process. The common types include oil circuit breakers, air circuit breakers, vacuum circuit breakers, and SF_6 circuit breakers. Circuit breakers can be enclosed in switchgear or can stand alone.

Oil circuit breakers (OCB) interrupt current under oil and use the gas generated by the decomposition of the oil to assist in arc extinguishing.

Air insulated circuit breakers are generally found at distribution system voltages and below. Air-type circuit breakers fall into two classifications: Air-blast and Air-magnetic.

Air-blast circuit breakers use compressed air as the quenching, insulating and actuating mechanism. In a typical device, a blast of air carries the arc into an arc chute to be extinguished. Air-blast circuit breakers at distribution voltages are often in metal-enclosed switchgear.

Air-magnetic circuit breakers use the magnetic effect of the current undergoing interruption to draw an arc into an arc chute for cooling, splitting and extinction. Sometimes, an auxiliary puffer or air-blast piston may help interrupt low-level currents. The air-magnetic circuit breakers have short duty cycles, require frequent maintenance, and approach their end-of-life at much faster rates than either SF_6 or vacuum circuit breakers. They also have limited transient recovery voltage capabilities and can experience re-strike when switching capacitive currents.

SF_6 circuit breakers interrupt currents by opening a blast valve and allowing high pressure SF_6 to flow through a nozzle along the arc drawn between fixed and moving contacts. This process rapidly deionizes, cools, and interrupts the arc. After interruption, low-pressure gas is compressed for re-use in the next operation. SF_6 is, however, a very potent greenhouse gas, having a global warming potential of about 23,500 times that of carbon dioxide[3]. It is very important that any gas leaks are mitigated promptly.

In vacuum circuit breakers, the parting contacts are placed in an evacuated chamber (i.e., vacuum bottle). There is generally one fixed and one moving contact in a butting configuration. A bellows attached to the moving contact permits the required short stroke to occur while maintaining the vacuum. Arc interruption occurs at current zero after withdrawal of the moving contact. Vacuum circuit breakers are also safer and protective of the environment.

6.2.2 Asset Degradation

Circuit breakers “make” and “break” high currents and experience erosion caused by the arcing accompanying these operations. All circuit breakers undergo some contact degradation every time they open to interrupt an arc. Also, arcing produces heat and decomposition products that degrade surrounding insulation materials, nozzles, and interrupter chambers. The mechanical energy needed for the high contact velocities of these assets adds mechanical deterioration to their degradation processes.

[3] United Nations Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5)

Outdoor circuit breakers may experience adverse environmental conditions that influence their rate and severity of degradation. Additional degradation factors for outdoor-mounted circuit breakers include corrosion, effects of moisture, bushing, insulator, and mechanical deterioration.

Corrosion and moisture commonly cause degradation of internal insulation, circuit breaker performance mechanisms, and major components such as bushings, structural components, and oil seals. Another widespread problem involves corrosion of operating mechanism linkages that result in eventual link seizures. Corrosion also causes damage to metal flanges, bushing hardware, and support insulators.

Outdoor circuit breakers experience moisture ingress through defective seals, gaskets, and pressure relief and venting devices. Moisture in the interrupter tank can lead to general degradation of internal components.

Mechanical degradation presents greater end-of-life concerns than electrical degradation. Operating mechanisms, bearings, linkages, and drive rods represent components that experience most mechanical degradation problems. Other effects that arise with aging include loose primary and grounding connections, oil contamination and/or leakage (oil circuit breakers only), and deterioration of concrete foundation affecting circuit breaker stability.

For oil circuit (OCB) breakers, the interruption of load and fault currents involves the reaction of high pressure with large volumes of hydrogen gas and other arc decomposition products. Thus, both contacts and the insulation medium degrade more rapidly in OCBs than they do in vacuum designs, especially when the OCB undergoes frequent switching operations. Generally, four to eight fault interruptions with contact erosion and oil carbonization will lead to the need for maintenance, including oil filtration. OCBs can also experience restrike when switching low load or line charging currents with high recovery-voltage values; this can lead to catastrophic circuit breaker failures.

6.2.3 Asset Class Demographics

Alectra's distribution system has 1,277 installed circuit breakers at its stations, 236 of which are associated with transformer stations. Figure 30 illustrates the age distribution of circuit breakers at stations. 187 circuit breakers are shown to exceed the TUL of 40 years, of which 59 exceed the EUL of 60 years, representing 14.6% and 4.6%, respectively, of the total installed population.

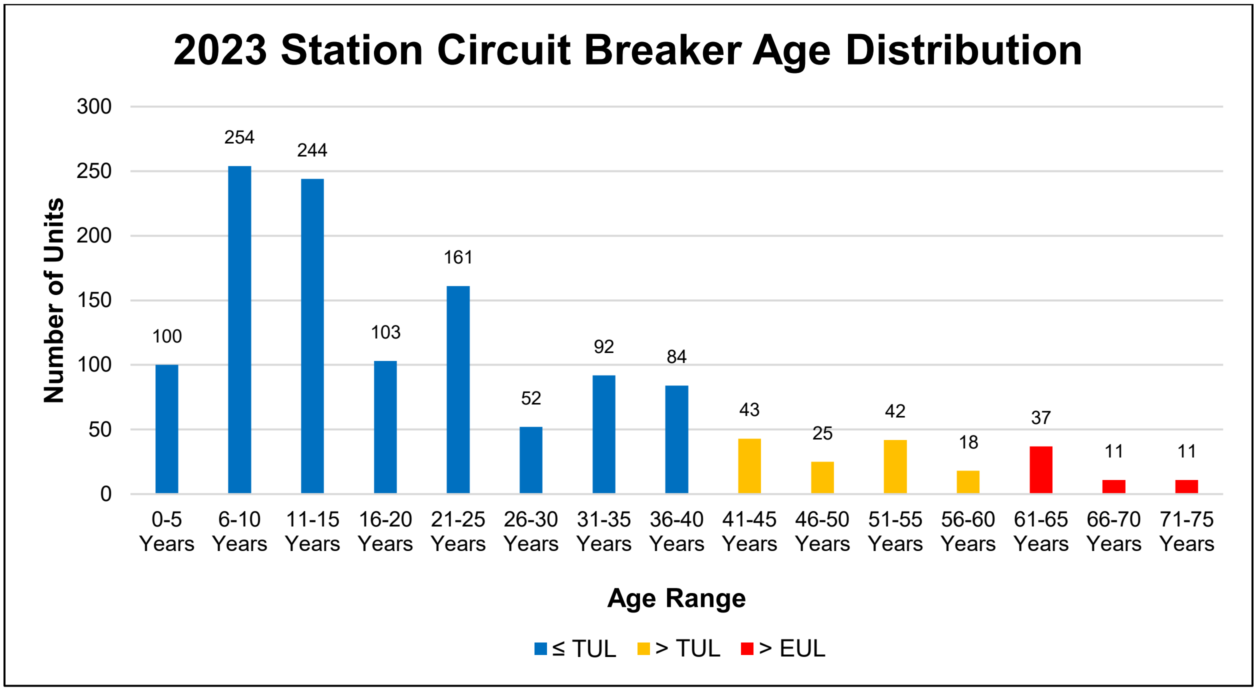

Figure 30 Station Circuit Breaker Age Distribution for 2023

6.2.4 Health Index Formula and Results

Health index of circuit breakers assesses the condition of the circuit breaker according to six main components: Insulation, Operating mechanism, Contact performance, Arc extinction, Oil leaks (where applicable), and Overall performance. Circuit breakers are analyzed separately. Sufficient condition information without age is now available for all circuit breakers.

The Health Index is computed by adding the weighted components of overall condition, as indicated in Table 12.

Table 12 Circuit Breaker Health Index Parameters and Weights

#	Input	Input Weight (OIL)	Input Weight (AIR)	Input Weight (Vacuum)	Input Weight (SF_6)	Input Weight (Switch & Fuse)
1	Insulation	4.8%	5.6%	7.4%	6.1%	6.7%
2	Operating Mechanism	33.3%	38.9%	25.9%	33.3%	46.7%
3	Contact Performance	16.7%	19.4%	25.9%	21.2%	23.3%
4	Arc Extinction	21.4%	16.7%	14.8%	18.2%	-
5	Oil Leaks	7.1%	-	-	-	-
6	Service Record	16.7%	19.4%	26.0%	21.2%	23.3%

Breaker Operations Multiplier

The maximum number of breaker operations during fault conditions depends on current magnitude. IEEE Standards C37.04, C37.010, and C37.60 provide guidelines for fault interrupting duty and maintenance intervals. These guidelines, in conjunction with typical breaker life-cycle curves, are used to derive the maximum fault operations, by breaker type, provided in Table 13. Number of circuit breaker operations is a dominant condition factor. If the number of breaker operations during fault conditions is within 75% of the maximum number of operations shown in this table, then the breaker is considered to be in Very Poor condition and will have a maximum Health Index of 10% (i.e., the calculated Health Index is multiplied by 0.1).

Table 13 Typical Circuit Breaker Maximum Number of Fault Operations

Breaker Type	Maximum Fault Operations
Vacuum	1200
SF_6	1000
Oil	700
Air	700
Recloser	116

Obsolescence Multiplier

A circuit breaker may be deemed obsolete if it is no longer supported by the manufacturer, parts are no longer readily available, and/or no longer meet current safety or performance standards. In condition assessments conducted in previous years, a circuit breaker deemed to be obsolete, was assigned a maximum Health Index of 50% (i.e., the calculated Health Index was multiplied by 0.5). An obsolescence multiplier is no longer applied to the Health Index for circuit breakers. Obsolescence continues to be a consideration in the circuit breaker renewal strategy but is now separated from the condition assessment and calculation of Health Index. For this reason, fewer circuit breakers are in the Very Poor and Poor condition categories in 2023 than in previous years. It is important to note that the inclusion of the Obsolescence Multiplier in previous years did not result in any unnecessary or premature expenditures.

Figure 31 illustrates the Health Index distribution of circuit breakers, classified from Very Poor to Very Good. 114 circuit breakers are shown to be in the Very Poor or Poor category. All 114 are enclosed in municipal station switchgear.

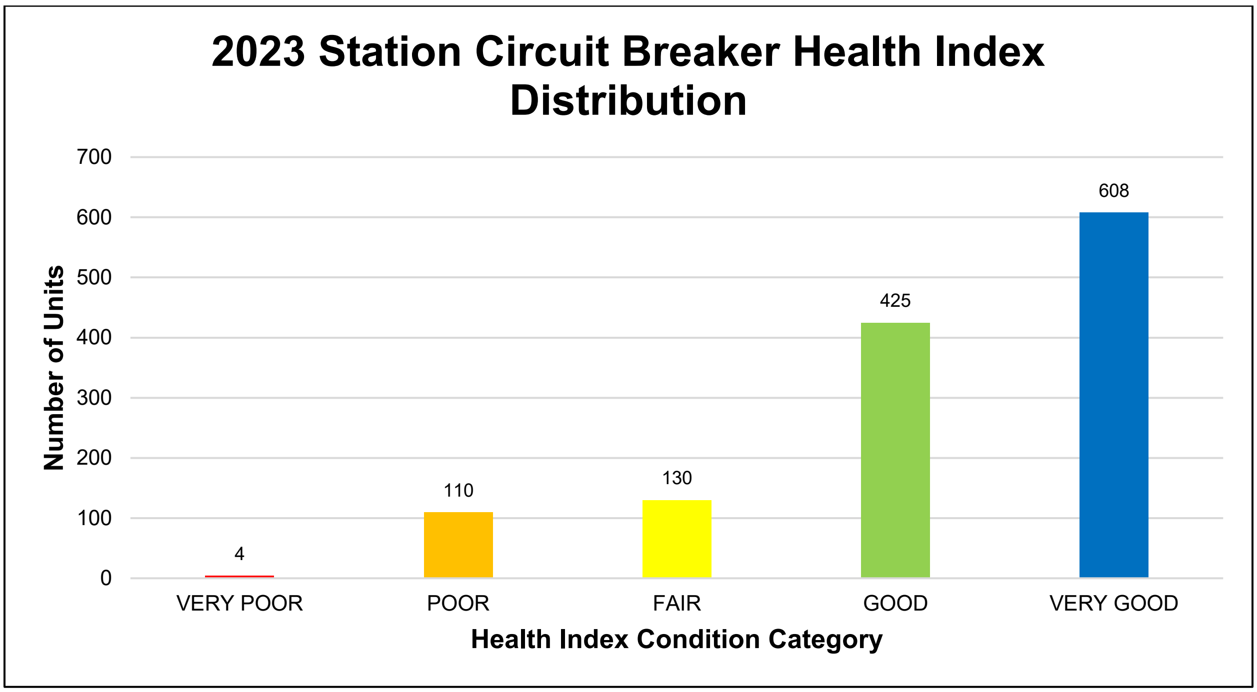

Figure 31 Station Circuit Breaker Health Index Distribution for 2023

Typically, circuit breaker replacement for units that are enclosed in station switchgear will trigger replacement of the entire switchgear lineup, including associated protections and ancillary equipment. Replacing the entire switchgear lineup rather than retrofitting the switchgear with new circuit breakers brings this station equipment up to current operating and safety standards.

6.3 Station Switchgear

6.3.1 Summary of Asset Class

Station switchgear consists of an assembly of retractable/racked devices that are totally enclosed in a metal envelope (metal-enclosed). These devices operate in the medium-voltage range, from 4.16 kV to 44 kV. Station switchgear includes circuit breakers, disconnect switches or fuse gear, current transformers (CTs), potential transformers (PTs), and occasionally some or all the following: Metering, Protective relays, Internal DC and AC power, Battery charger(s), and AC station service transformation. Station switchgear is modular in that each circuit breaker is enclosed in its own metal envelope (cell). Station switchgear is also compartmentalized, having separate compartments for circuit breakers, control, incoming/outgoing cables or bus duct, and busbars associated with each cell.

6.3.2 Asset Degradation

Station switchgear degradation is a function of several factors: Mechanism operation and performance, Degradation of solid insulation, General degradation/corrosion, Environmental factors, and Post fault maintenance (condition of contacts and arc control devices). Degradation of the circuit breaker used is also a factor. However, the degradation mechanism differs slightly between air-insulated and gas-insulated switchgear types. Alectra evaluates circuit breakers separately from station switchgear.

The greatest cause of station switchgear failure is related to mechanism malfunction. Deterioration due to corrosion or to lubrication failure may compromise mechanical performance by either preventing or slowing down the operation of the circuit breaker. This is a serious issue for all types of station switchgear.

In older air-filled equipment, degradation of active solid insulation, such as drive links, has been a significant problem for some types of station switchgear. Some of the materials used in this equipment, particularly those manufactured using cellulose-based materials, such as Solid Resin Impregnated Pressboard (SRBP) and laminated wood, are susceptible to moisture absorption. This results in a degradation of their dielectric properties, resulting in thermal runaway or dielectric breakdown. An increasingly significant area of solid insulation degradation relates to the use of more modern polymeric insulation. Polymeric materials, which are now widely used in station switchgear, are very susceptible to discharge damage. These electrical stresses must be controlled to prevent any discharge activity in the vicinity of polymeric material. Failures of relatively new station switchgear due to discharge damage and breakdown of polymeric insulation have been relatively common over the past couple of decades.

Temperature, humidity, and air pollution are also significant degradation factors. The safe and efficient operation of station switchgear and its longevity may all be significantly compromised if the station environment is not adequately controlled.

6.3.3 Asset Class Demographics

Alectra's distribution system has 365 station switchgear. Figure 32 illustrates the age distribution of station switchgear. 93 station switchgear are shown to exceed the TUL of 40 years, of which 21 exceed the EUL of 60 years, representing 25.5% and 5.8%, respectively, of the total installed population.

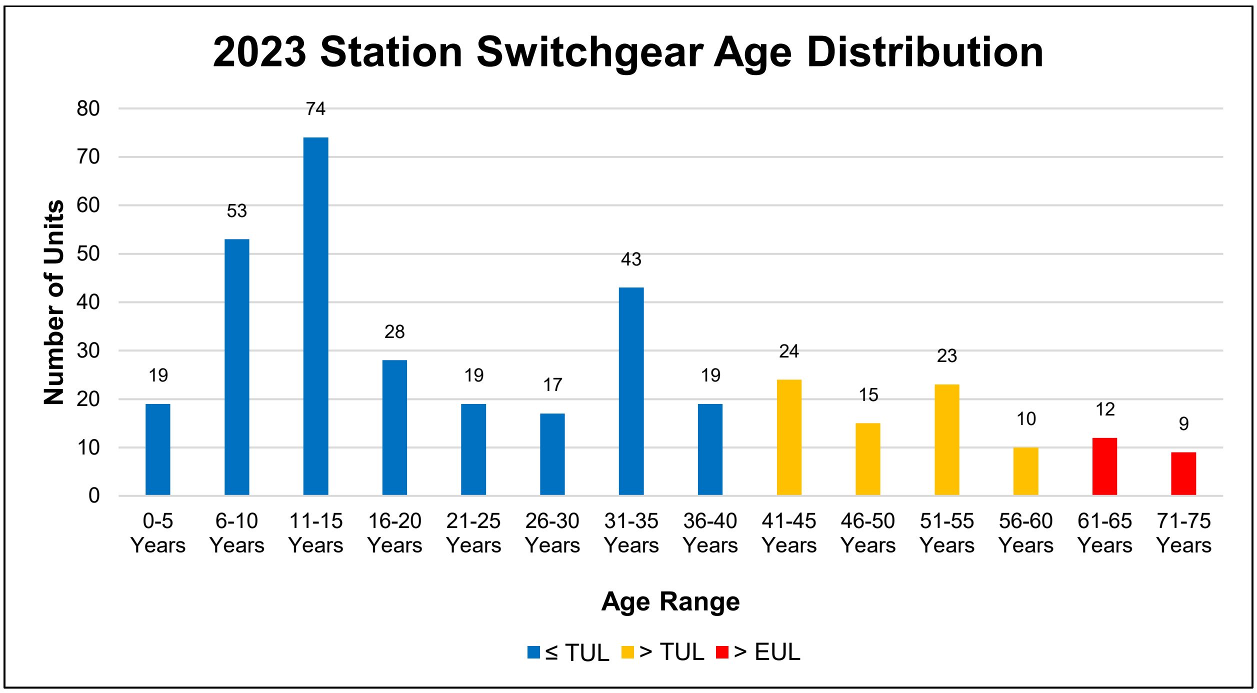

Figure 32 Station Switchgear Age Distribution for 2023

6.3.4 Health Index Formula and Results

Health index of station switchgear assesses the condition of the switchgear according to five main components: Enclosure condition, Bus and cable compartment, Low-voltage compartment, and Overall Performance. The station switchgear ACA model does not include the enclosed circuit breakers; circuit breakers are considered separately in the circuit breaker ACA model.

The Health Index is computed by adding the weighted components of overall condition, as indicated in Table 14.

Table 14 Station Switchgear Health Index Parameters and Weights

#	Input	Input Weight
1	Enclosure Condition	25%
2	Bus & Cable Compartment	37.5%
3	Low Voltage Compartment	12.5%
4	Service Record	25%

Figure 33 illustrates the Health Index distribution of station switchgear, classified from Very Poor to Very Good. 39 station switchgear are shown to be in the Poor category. This compares with 36 in the Poor category in 2018. This increase is despite having replaced 11 station switchgear since 2018, indicating the ongoing need for replacements to address the rate of asset deterioration.

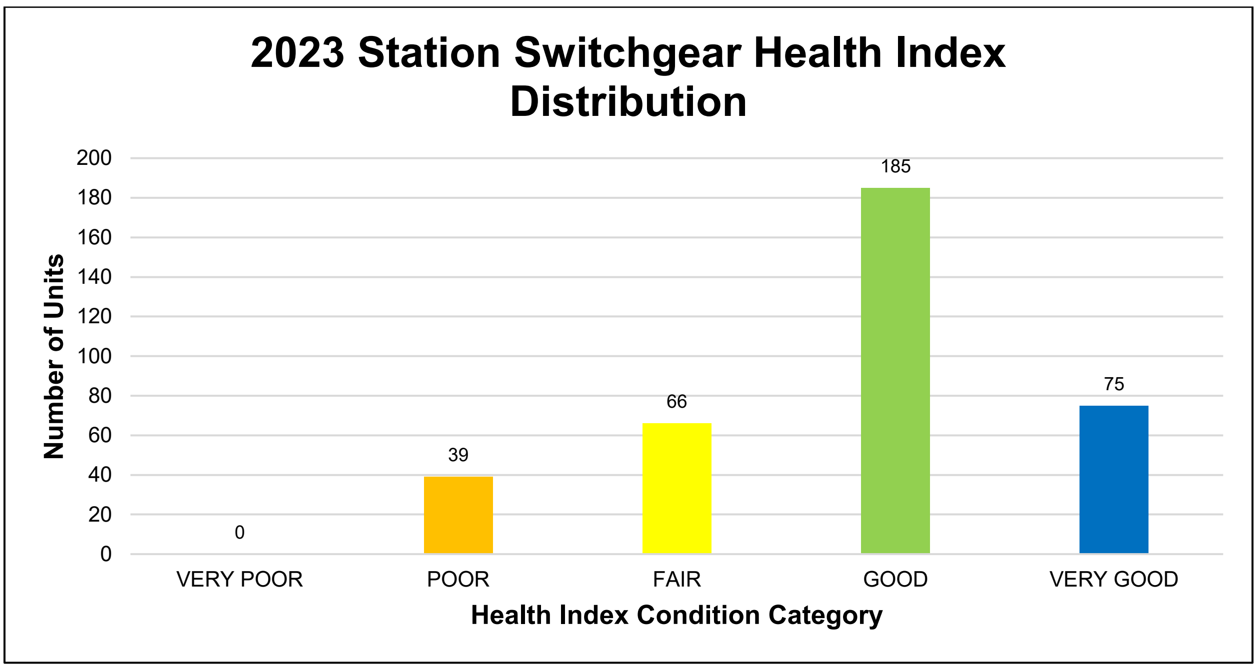

Figure 33 Station Switchgear Health Index Distribution for 2023

Proactive station switchgear replacement involves replacing the circuit breakers, associated protections, and ancillary equipment and is typically driven by the need to replace the circuit breakers.

Appendix F

Alectra 2024 Health Index Methodology Review

ALECTRA 2024 HEALTH INDEX METHODOLOGY REVIEW

K-814516-RA-0001 D00

Issue Date

2 September 2025

Prepared by	Reviewed by	Approved by
Signature	*Signature*	*Signature*
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Distribution Asset Management	Distribution Asset Management	Distribution Asset Management
2025-09-02	2025-09-02	2025-09-02

DISCLAIMER

1 INTRODUCTION

Alectra Utilities Corporation (Alectra) is an electrical Local Distribution Company (LDC) that serves over one million customers in seventeen Ontario communities. As such, Alectra manages a multi-billion-dollar asset base across a 1,900 square kilometer service territory.

To support capital investment requirements for sustaining existing asset base in the most cost-effective manner, Alectra utilizes Health Indexing (HI) for determining the condition of assets and identifying specific assets that require attention. HI methodology involves using available condition data and information, such as visual inspection records, test results, and historical utilization, that feed into HI formulae and generate quantitative scores for asset condition. The score ranges from 0 to 100, where 0 represents an asset showing signs of major degradation or in critical condition demanding intervention, and 100 represents an asset with no signs of degradation.

Kinectrics Inc. (Kinectrics) was retained to conduct a third-party review of Alectra's HI methodology used for assessing the condition of its assets and how Alectra's HI methodology compares with best industry practices. Kinectrics has performed dozens of Asset Condition Assessments (ACAs) using HI for many Ontario LDCs as well as for utilities across North America. A summary of Kinectrics credential as well as short bios of its principal team members involved with this project are provided in Appendix A.

This report documents Kinectrics' observations and findings of Alectra's HI methodology.

2 SCOPE

Kinectrics was asked to review HI formulae, types of input data, and information used in Alectra's HI methodology for the following station and distribution asset categories:

Table 1 List of Asset Categories under Review

Distribution Assets	Station Assets
Pad-mounted Transformers Pole-mounted Transformers Vault Transformers Switchgear Overhead Switches Overhead Conductors Wood Poles Concrete Poles Underground Primary Cables	Power Transformers (TS and MS) Circuit Breakers/Reclosers Station Switchgear

3 OBSERVATIONS AND EVALUATION

3.1 Alectra HI Formulae Evaluation

Alectra provided Kinectrics with two documents: Distribution Assets Health Index Computational Methodology and Station Assets Health Index Computational Methodology. The HI methodologies described in these documents are similar and share the same general HI formula shown in Equation 1 and the same five (5) HI results categories (i.e., “very poor”, “poor”, “fair”, “good” and “very good”) derived from predetermined bands of HI scores shown below in Table 2.

$$HealthIndex = \frac{\sum_{i=1}^{n}(InputWeight_i \times InputScore_i)}{\sum_{i=1}^{n} InputWeight_i} \times ConditionMultiplier$$

Equation 1

Where “n” is the number of inputs associated with each asset category, and a condition multiplier is applied when a dominant factor indicates a greater degree of asset deterioration than indicated by the calculated HI.

Table 2 Health Index Categories

Category	Criteria	Range
Very Good	Assets with no signs of deterioration.	$HI \geq 85\%$
Good	Asset still in solid working condition with minimal signs of wear.	$70\% \leq HI < 85\%$
Fair	Asset functional but showing clear signs of deterioration.	$50\% \leq HI < 70\%$
Poor	Assets exhibiting significant degradation requiring attention.	$25\% \leq HI < 50\%$
Very Poor	Assets showing major degradation or critical condition demanding urgent intervention.	$HI < 25\%$

However, there are some differences between the two methodologies:

- For station assets, due to the abundance of both visual inspection records and testing results, the HI methodology involves first determining input scores, as shown in Equation 2, and then using these input scores in calculating the overall HI score:

$$\text{Input Score}_n = \frac{\sum_{m=1}^{y}\left(\frac{(\text{Secondary Input Score})_m}{(\text{Maximum Secondary Input Score})_m} \text{ x } (\text{Secondary Input Weight})_m\right)}{\sum_{m=1}^{y}((\text{Secondary Input Weight})_m)}$$

Equation 2

- For distribution assets, very limited test data are available (except for a sample of wood poles) so the HI formulae were based on a combination of visual inspection results and ageing values derived from asset category-specific Typical Useful Life (TUL) and End of Useful Life (EUL) ages from Kinectrics' report titled "Asset Depreciation Study for the Ontario Energy Board"[1].

3.2 Findings

The Kinectrics review focused on the following aspects of the HI formulae for each asset category listed in Table 1:

- Input Data
  Whether appropriate condition data are used to assess the condition of assets.

- Input Weights
  Whether the relative magnitudes of the weights properly reflect the importance of the associated inputs in estimating the condition of assets.

- Test Results Interpretation
  Whether the raw data obtained through tests on station assets are appropriately interpreted in generating secondary input scoring.

- Inspection Records Analysis
  Whether the raw data obtained through visual inspection on both station and distribution assets are properly analyzed in generating input scoring.

- Scoring Criteria
  Whether the point-based Step Scoring criteria and the Percentage Scoring modelling reasonably represent parameters scoring.

- Overall Score Adjustment
  Whether Condition Multipliers effectively identify units that require immediate attention based on triggering certain parameter conditions.

Kinectrics' opinion is that all the above-mentioned aspects of the HI formulae used were well aligned with the best industry practices and represent a sound methodology for assessing the condition of individual assets.

---

[1] Kinectrics Inc., *Asset Depreciation Study for the Ontario Energy Board*", K-418033-RA-001-R000 (July 8, 2010).

Kinectrics identified a few instances of inconsistencies, typos, inadequate explanation, improper labelling, and need for clarification within their written process documents which had no impact on the HI results but required correction to avoid confusion. Additionally, regarding station assets, Kinectrics found that the following two important inputs used by most utilities were not included in Alectra's HI formulae:

1. Continuous current loading for station power transformers
2. Number of operations for circuit breakers/reclosers

Although not as important in establishing assets condition as the results of testing and inspection records inputs that were already included in the Alectra's HI formulae, these inputs are also extremely relevant. They indicate the extent of historical loading or utilization of assets which plays a role in their long-term deterioration.

Kinectrics informed Alectra of the above issues requiring clarification, as well as the need to add the above-mentioned two inputs for station power transformers and circuit breakers/reclosers models.

Alectra provided all the required clarifications identified by Kinectrics.

With regard to the station asset inputs, Alectra spent significant efforts mining historical data for information regarding station power transformer loading and circuit breakers/reclosers operations count. Alectra then independently developed methodology and HI formulae adjustments for the station power transformer and the circuit breaker HI models to include the new inputs, assigning weights to these inputs, and adjusting the original input weights. The modifications have resulted in Alectra now having a HI methodology for station power transformers and circuit breakers/reclosers that is superior to those used by other utilities for the following reasons:

- Alectra's transformers' loading input was based on daily peaks as opposed to monthly peaks typically used by other utilities. This approach provides a much better measure of loading variations.

- Alectra's circuit breakers/reclosers operations count considers fault operations whereas other utilities only consider the total count of operations. This is a very significant improvement over the typical approach because fault operations cause accelerated deterioration.

Having these inputs incorporated in the HI formulae increases the credibility of results and sets Alectra as an industry leader in assessing condition of station power transformers and circuit breakers/reclosers. It is also worth noting that, according to Alectra, the updated HI formulae did not affect the HI results nor any previously made investment decisions.

4 CONCLUSION

Following the detailed review of Alectra's HI methodology for station and distribution assets, Kinectrics is of the opinion that the HI methodology used is aligned well with best industry practices and in the case of station power transformers and circuit breakers/reclosers, represents the industry's leading edge in HI modelling. It is our understanding that the HI methodology forms the basis for Alectra's Asset Condition Assessment report. Given the high quality of the HI methodology, the ACA results should be highly credible.

APPENDIX A

Kinectrics' HI methodology has been well received by the Ontario Energy Board (OEB) in evaluating LDCs rate cases. Furthermore, Kinectrics has served as a Vendor of Record (VOR) for the OEB, and in this capacity reviewed several ACAs produced by LDCs without Kinectrics involvement. Kinectrics' HI methodology was found to be more robust than the ones adopted by most of these LDCs. Finally, Kinectrics' HI methodology was incorporated in reports of international industry organizations Conseil International des Grandes Reseaux Electriques (CIGRE) and Centre for Energy Advancement through Technological Innovation (CEATI) and was shared with great success at many industry forums, such as Institute of Electrical and Electronics Engineers (IEEE), Electric Utility Consultants Inc (EUCI), Edison Electric Institute (EEI), CEATI and CIGRE. In summary, Kinectrics, as a recognized industry leader in all aspects of Asset Management, has a good understanding of what are good industry practices regarding HI methodology.

Yury Tsimberg, P. Eng., M. Eng.

Yury Tsimberg is a Founder and President of the consulting firm YULA PLT CONSULTING INC specializing in providing consulting services to electrical utilities and associated industry organizations in all areas of Asset Management for transmission and distribution assets. The scope of his activities includes guiding utilities in developing Strategic Asset Management Plan and Asset Management Plans in accordance with ISO55000 standards, facilitating risk-based investment prioritization using PROSORT or similar products, reviewing ACA reports and, for LDCs in Ontario, developing and reviewing Distribution System Plans (DSPs).

Immediately prior to founding YULA PLT CONSULTING INC, Yury was a Director of Asset Management with Kinectrics Inc. where for several years he has been leading corporate consulting services in the Asset Management area. In this capacity, he successfully completed many Asset Management projects across North America and Europe, including preparing ACA reports and, specifically for LDCs in Ontario, developing and reviewing DSPs as well as reviewing DSPs prepared by LDCs on behalf of the OEB as the OEB's Vendor of Record.

Yury taught Asset Management courses all over the world and was a presenter at many industry conferences and forums, such as CIGRE, IEEE, CEATI, EEI and EUCI. He also authored and co-authored many published papers in industry magazines and forums, such as CIGRE, IEEE and CEATI.

Prior to joining Kinectrics, Yury spent 30 years with Ontario Hydro and Hydro One working in various areas of the electrical utility transmission and distribution business, including transmission lines maintenance, system planning, power system operations, M&A, Regulatory, and Customer Service. In his last position at Hydro One, he headed a department responsible for the development and implementation of corporate Asset Management strategies, methodologies, new standards and policies, and leading public consultation processes associated with major projects.

Yury Tsimberg was a Canadian member of the international panel revising PAS 55 specification, Canadian representative on North American Electrical Reliability Corporation (NERC) Committees developing the North American transmission planning standard currently known as TPL-001, and Canadian representative and management team member on the Asset Management Convener for International Council on CIGRE Study Committee C1 "System Development and Economics". In 2018, he was awarded a prestigious CIGRE Technical Council Award in recognition of his outstanding contribution to CIGRE's work. Yury was a Convener of CIGRE's Working Group C1.43 "Requirements for Asset Analytics data platforms and tools in electric power systems" that produced CIGRE Technical Brochure TB910 and is currently a Co-Convener of CIGRE Joint Working Group B2/C1.86 "Approach to Asset Management of Overhead Transmission Lines".

Yury holds Bachelor of Applied Science and Master of Engineering Degrees in Electrical Engineering from the University of Toronto and is a Registered Professional Engineer in the Province of Ontario, Canada. He also holds an Asset Management Certificate from the Institute of Asset Management and was recognized in the past by the OEB as Expert Asset Management witness.

Fan Wang, P.Eng. Ph.D.

Fan Wang is a senior engineer/scientist in the Transmission & Distribution Technologies Division of Kinectrics Inc. He joined Kinectrics in 2007 and since then has been working on a number of Asset Management projects with many utilities across North America. His expertise includes condition assessment, risk assessment, equipment testing and technical specification evaluation for all the major transmission and distribution equipment categories.

Fan Wang also has extensive experience in the areas of power quality, distributed generation, arc flash study, protective relaying, condition monitoring and maintenance schemes of substation automation systems, IEC 61850 certification and Real-Time Digital Simulator (RTDS) / Power Systems Computer Aided Design (PSCAD) modeling. He has worked as an electrical engineer specializing in the design and on-site commissioning of power plants and substations. He was the project leader for an electrical power system design for power plants and substations in China. Immediately prior to joining Kinectrics, he worked at Honeywell as a systems engineer, working on failure root cause analysis and troubleshooting for secondary electric power distribution centers on Airbus commercial jumbo jet plane A-380, and was on site in Toulouse for technical support. Being an experienced RTDS / PSCAD user, Fan Wang is an expert in power systems studying and modeling, and has been involved in connection impact assessment, equipment arc hazard study, and IEC 61850 based substation automation system projects.

Fan Wang received his B.Eng. degree from Tsinghua University in China, M.Eng. Degree from National University of Singapore in Singapore, and Ph.D. degree from Chalmers University of Technology in Sweden, all in electrical engineering. He is a Registered Professional Engineer in the Province of Ontario, and a member of IEEE and CIGRE. He also holds an Asset Management Certificate from the Institute of Asset Management.

Appendix G

Climate Risk & Vulnerability Assessment

Report

Climate Risk and Vulnerability Assessment of the Alectra Utilities' Distribution System

July 3, 2025

Disclaimer

This report (the "Study") was prepared by Hatch Ltd. ("Hatch"), for the sole and exclusive benefit of Torys LLP ("Torys", or "Client") and its client Alectra Utilities Inc. ("Alectra") for the purpose of Alectra's application to the Ontario Energy Board for approval of 2027-2031 electricity distribution rates and may not be relied upon by any third party.

Any use of this report by the Client and/or Alectra is subject to the terms and conditions of the Agreement for the Purchase (450068 OS) of Services between Hatch and the Client and/or Alectra dated December 13, 2023, including the limitation on liability set out therein.

This report includes information provided by Client and/or Alectra and publicly available information. In preparing the Report, Hatch has relied upon the accuracy and quality of this information to perform this assessment. Unless specifically stated otherwise, Hatch has not verified the accuracy or completeness of such information and disclaims any responsibility or liability in connection with such information.

The material in this Report reflects Hatch's professional judgment based upon information available at the time of its preparation and for the production period identified herein. The accuracy of our findings and professional opinions depends on the background data assumptions and the quality of data collected.

This report is meant to be read as a whole, and sections should not be read or relied upon out of context. The opinions in this Report are based on conditions existing at the time of the report and do not consider any subsequent changes. The quality of the information, conclusions, and recommendations contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared. No representations or predictions are intended as to the results of future work, nor can there be any promises that the estimates and projections in this report will be sustained in the future.

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List of Acronyms

ACA	Asset Condition Assessment
BCCAQ	Bias Correction/Constructed Analogues with Quantile Mapping
CI	Customers Interrupted
CMIP	Coupled Model Intercomparison Project
DER	Distributed Energy Resource
ECCC	Environment and Climate Change Canada
IPCC	Intergovernmental Panel on Climate Change
MED	Major Event Day
PIEVC	Public Infrastructure Engineering Vulnerability Committee
RCP	Representative Concentration Pathways
SME	Subject Matter Expert
SSP	Shared Socio-Economic Pathway
SOP	Standard Operating Procedure
Weka	Waikato Environment for Knowledge Analysis

Executive Summary

Over one million homes and businesses rely on Alectra Utilities' (Alectra's) distribution system for the delivery of electrical services. Interruptions in such services pose immediate impacts to households and businesses. With climate change and a shift in weather patterns, more climate-related outages are expected. For example, storms can damage power lines causing outages/blackouts, high winds can cause trees to fall damaging distribution assets, etc. It is important to understand how such events can impact the distribution system to be able to plan for a more resilient grid.

Hatch was engaged to assess the vulnerability of Alectra's distribution system to evolving weather patterns as a result of climate change, which will influence adaptation plans and enable Alectra to make informed decisions across the organization.

The scope of work to assess the impact of climate parameters on Alectra's distribution network included four (4) major activities:

1. Service Area Boundary Definition
2. Climate Analysis
3. Outage Data Analysis
4. Risk Assessment

The service area boundary definition focused on outlining Alectra's service territory, grouping the 17 communities across Ontario into 14 service zones that represent the geographic locations Alectra provides distribution services to (Service Zone Level). Each service zone was further divided into multiple grid cells spanning 10 km x 6 km in size (Grid Cell Level analysis).

Climate projections were developed using climate models based on a grid that covers a region of the earth, encompassing an area of 10 km x 6 km. The climate scenarios used in this Study are the Intergovernmental Panel on Climate Change (IPCC) scenarios SSP1-2.6, SSP2-4.5 and SSP5-8.5. Where possible, these climate scenarios were used to obtain the historical and projected climate conditions. Where data was not available through climate models (e.g., tornadoes, derechos, and ice storms), historical observed climate data and literature review using specialized datasets were leveraged.

Single and multi-variable analysis methods were used to determine correlations between historical outage events and related climate parameters. For locations where sufficient data was not available, clustering results from neighboring areas were leveraged to approximate the impacts, taking into consideration the differences in overhead and underground distribution. The outage data analysis provided quantitative metrics that represent the impact of each climate parameter on Alectra's distribution network, to be used for risk profiles. For this Study, the consequence of a climate event affecting Alectra's distribution system was based on the number of customers interrupted (CI), and it did not include allowances for maintenance effort or capital outlay. This is due to this Study focusing on the reliability of the distribution system affecting Alectra's customers, rather than the financial impacts of post-event mitigation through capital and operations & maintenance (O&M) costs. Additional failure consequences, such as safety, environmental, public perception, etc. have not been considered as part of the analysis.

The vulnerability of Alectra's distribution system was reviewed using a risk assessment methodology, where probability of occurrence of a climate parameter was coupled with the consequence of the impact on the system (as measured by CI). The resulting risk ratings were classified as very high, high, moderate, low, and very low.

Under current climate conditions, very high risks to Alectra's distribution system were identified under high wind conditions (101 to 121 km/h) for Mississauga and Brampton. These risks remain very high in projected climate conditions. In addition, high risks to Alectra's distribution system were identified for temperatures above 32°C, varying thresholds of wind gusts, high precipitation, and ice storms. These risks remain high in projected climate conditions. In addition, Mississauga and Brampton will observe an increase in the risk level associated with wind gusts over 121 km/h from moderate risk to high risk. Similarly, Hamilton will observe an increase in the risk level associated with precipitation above 50 mm from high risk to very high risk.

Under current climate conditions, the risk of tornadoes ranges from very low to low in most of Alectra's service zones, except for Barrie, where the risk of tornadoes was identified as moderate. Under projected climate conditions, these risks remain very low, low, and moderate, except for Barrie and Aurora, where the risks were identified as high under projected climate conditions.

Under current climate conditions, the risk of derechos in Alectra's distribution system ranges from very low to low. Under projected climate conditions, all the service zones will observe an increase in the risk level associated with derechos, ranging from moderate (Penetanguishene and Tottenham-Beeton) to very high (Mississauga and Hamilton). The remaining areas will observe a high risk associated with derechos under projected climate conditions.

A summary of the risk assessment results (as heat maps), has been provided in Table 0-1 and Table 0-2 for current climate condition and projected climate conditions, respectively.

Table 0-1: Risk Heat Map Profile for Baseline (1950-2020)

Location	Temperature (°C)		Wind (km/h)					Precipitation (mm)		Extreme Events		
	>32	>40	<60	61-80	81-100	101-120	>121	>20	>50	Tornado	Derecho	Ice Storm
Penetanguishene	Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Low	Low	Very Low	Very Low	Low
Barrie	Moderate	Very Low	Moderate	Moderate	Very Low	Very Low	Very Low	High	High	Moderate	Very Low	High
Alliston-Thornton	Low	Very Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	Low	Very Low	Moderate
Tottenham-Beeton	Low	Very Low	Low	Low	Low	Very Low	Very Low	Low	Low	Low	Very Low	Low
Bradford	Low	Very Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	Very Low	Very Low	Moderate
Aurora	Low	Very Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	Low	Very Low	High
Markham	Moderate	Very Low	Moderate	High	High	Very Low	Very Low	Low	Moderate	Low	Low	High
Richmond Hill	Low	Very Low	High	High	High	Very Low	Low	Moderate	High	Very Low	Low	High
Vaughan	Moderate	Very Low	Moderate	High	High	Very Low	Very Low	High	High	Low	Low	High
Brampton	High	Very Low	Low	Moderate	Moderate	Very High	Moderate	High	High	Low	Low	High
Mississauga	High	Very Low	Moderate	High	Very High	Very High	Moderate	High	High	Low	Low	High
Guelph-Rockwood	Moderate	Very Low	Moderate	High	High	Very Low	Very Low	Moderate	Moderate	Very Low	Very Low	High
Hamilton	Moderate	Very Low	Moderate	High	Very Low	Low	Low	High	High	Low	Low	High
St. Catharines	Low	Very Low	Low	High	High	High	Very Low	Low	Moderate	Very Low	Very Low	High

Risk Profile Legend:
Very High; High; Moderate; Low; Very Low

Table 0-2: Risk Heat Map Profile for Study Period (2021-2075)

Location	Temperature (°C)		Wind (km/h)					Precipitation (mm)		Extreme Events		
	>32	>40	<60	61-80	81-100	101-120	>121	>20	>50	Tornado	Derecho	Ice Storm
Penetanguishene	Low	Low	Low	Low	Very Low	Very Low	Very Low	Low	Low	Low	Moderate	Low
Barrie	Moderate	Moderate	Moderate	Moderate	Very Low	Very Low	Very Low	High	High	High	High	High
Alliston-Thornton	Low	Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	Moderate	High	Moderate
Tottenham-Beeton	Low	Low	Low	Low	Low	Very Low	Very Low	Low	Low	Moderate	Moderate	Low
Bradford	Low	Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	Low	High	Moderate
Aurora	Low	Low	Low	Low	Moderate	Very Low	Very Low	Low	Moderate	High	High	High
Markham	Moderate	Moderate	Moderate	High	High	Very Low	Very Low	Low	Moderate	Moderate	High	High
Richmond Hill	Low	Moderate	High	High	High	Very Low	Low	Moderate	High	Low	High	High
Vaughan	Moderate	High	Moderate	High	High	Very Low	Very Low	High	High	Moderate	High	High
Brampton	High	High	Low	Moderate	Moderate	Very High	High	High	High	Moderate	High	High
Mississauga	High	High	Moderate	High	Very High	Very High	High	High	High	Moderate	Very High	High
Guelph-Rockwood	Moderate	High	Moderate	High	High	Very Low	Very Low	Moderate	Moderate	Very Low	High	High
Hamilton	Moderate	Moderate	Moderate	High	Very Low	Low	Low	High	Very High	Low	Very High	High
St. Catharines	Low	Moderate	Low	High	High	High	Very Low	Low	Moderate	Very Low	High	High

Risk Profile Legend:
Very High; High; Moderate; Low; Very Low

1. Introduction

1.1 Background

Approximately one million homes and businesses rely on Alectra's distribution system for the delivery of electrical services. Interruptions in such services pose immediate impacts to households and businesses. With the shift in weather patterns resulting from climate change, an increase in climate-related outages is expected (e.g., storms can damage power lines causing outages or blackouts, high winds can cause trees to fall damaging distribution assets, etc.). It is important to understand how such events could impact the distribution system to be able to plan for a more resilient grid.

The objective of this work was to assess the vulnerability of Alectra's distribution system to evolving weather patterns as a result of climate change, which will influence adaptation plans and enable Alectra to make informed decisions across the organization.

1.2 Project Scope

The scope of work to assess the impact of climate parameters on Alectra included the following:

- Identify applicable Intergovernmental Panel on Climate Change (IPCC) scenarios for trends and projections and examination of these trends in the context of Alectra's service zones.
- Identify relevant climate parameters and impact on Alectra's distribution system.
- Review historical climate information over a period of 71 years, and future climate information comprising of near term (2021-2040), mid-century (2041-2060), long term (2061-2075), and study period (2021-2075).
- Develop multiple climate projections and probability ranges for each climate parameter across the periods mentioned above.
- Conduct statistical analysis to assess the correlation between Alectra's historical outages and weather events.
- Perform a risk assessment study by developing a risk rating as a function of the probability of an unwanted incident and the severity of its consequence.
- Provide a general overview of potential risk mitigation strategies.

1.3 Sources of Information

Hatch utilized information that was publicly available and/or provided by Alectra. The following sources were referenced and/or considered to complete the assessment:

- Alectra Outage Data, 2016 – 2023.
- Alectra Major Event Reports, 2019 – 2022.

- Alectra Information and Demographics: Overhead (OH) Conductors, OH Switches, Poles, Switchgears, Transformers, Underground (UG) Cables, Vaults, Stations
- Alectra Municipalities Served.
- Census Profile, 2021[1].
- Historical Weather Data[2].
- IPCC 6th Assessment Report.
- Online data portals for climate projections and historical data.
- Specialized climate studies (literature review).

1.4 Alectra's Distribution System

Alectra provides distribution services to approximately one million homes and businesses across an approximately 1,900 square kilometer service territory comprising 17 communities including Alliston, Aurora, Barrie, Beeton, Brampton, Bradford West Gwillimbury, Guelph, Hamilton, Markham, Mississauga, Penetanguishene, Richmond Hill, Rockwood, St. Catharines, Thornton, Tottenham, and Vaughan. This service territory represents approximately 20% of the total number of distribution customers in Ontario.

For the purpose of this Study, the 17 communities were grouped into 14 service zones, as presented in Figure 1-1, representing the geographic locations Alectra provides distribution services to (Service Zone Level analysis). Each service zone is further divided into multiple grid cells, with each grid cell representing a computational unit of a climate model, spanning 10 km x 6 km in size (Grid Cell Level analysis). Each shaded region shown in Figure 1-1 represents a service zone, with the further breakdown into blocks showcasing the grid cells within each service zone.

[1] Census Profile, 2021 Census of Population (statcan.gc.ca)
[2] Climate data extraction tool - Daily climate data (canada.ca)

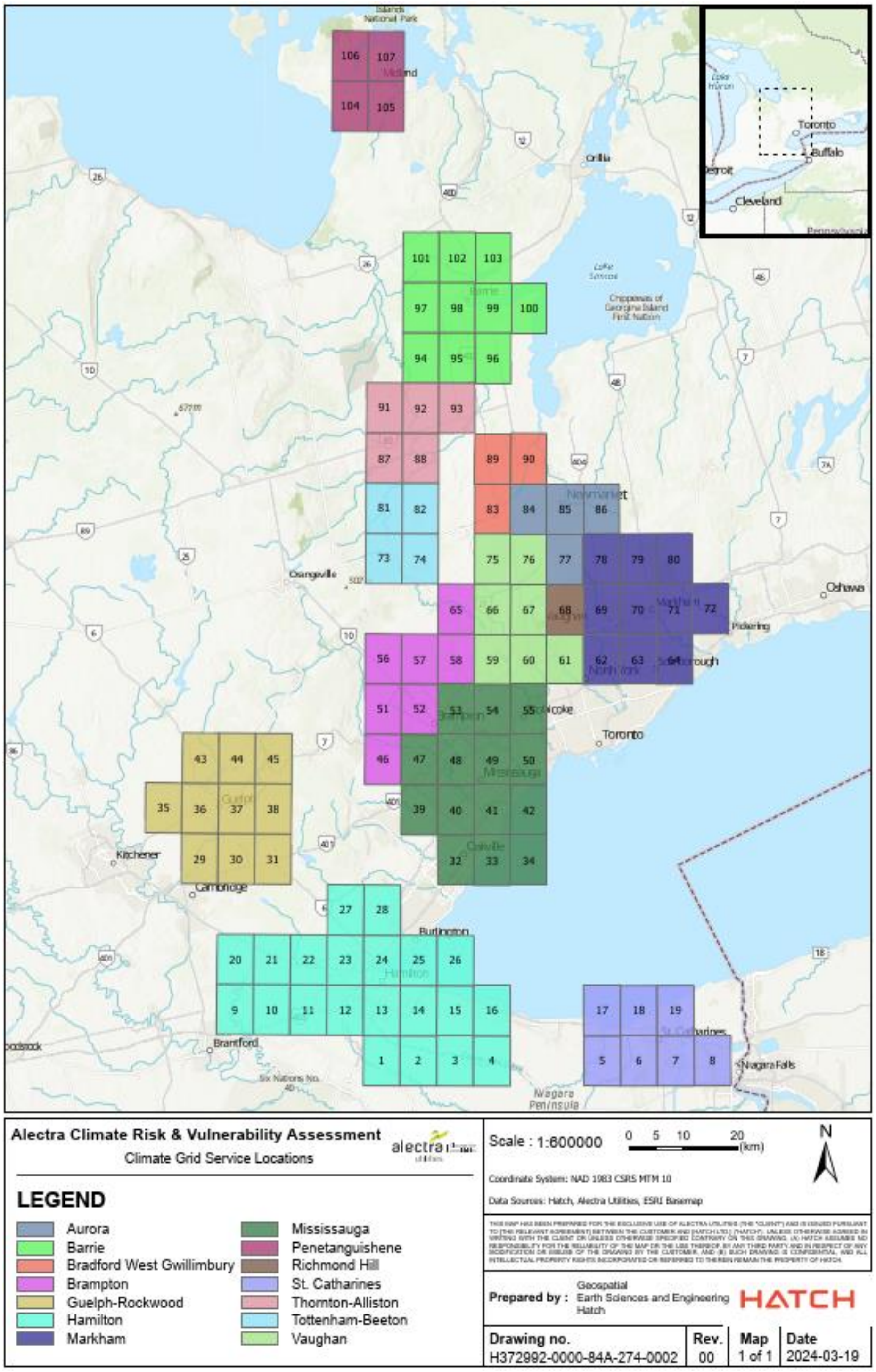


Figure 1-1: Climate Grid Service Locations

1.5 Overview of Methodology

To assess Alectra's vulnerability to climate change and evolving weather patterns, the methodology focused on leveraging a data-centric approach to determine the impact of the selected climate parameters on the system, under both current and projected climate conditions.

The scope of work included four (4) major activities, as summarized in Figure 1-1:

1. Service Area Boundary Definition
2. Climate Analysis
3. Outage Data Analysis
4. Risk Assessment

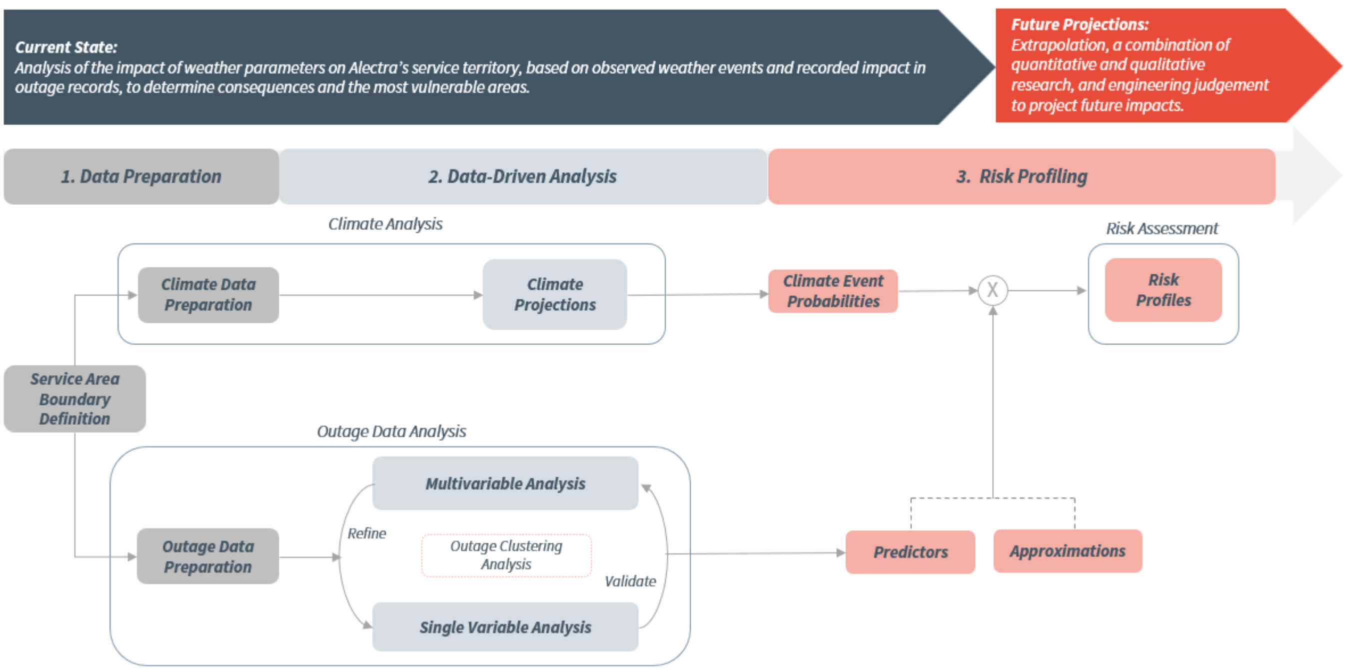


Figure 1-1: Methodology Overview

The service area boundary definition focused on outlining Alectra's service territory, grouping the 17 communities across Ontario into 14 service zones that represent the geographic locations Alectra provides distribution services to (Service Zone Level). Each service zone is further divided into multiple grid cells, with each grid cell representing a computational unit of a climate model, spanning 10 km x 6 km in size (Grid Cell Level analysis). This definition served as a basis for the analysis, used to combine the climate analysis and outage data analysis across a common service territory for the risk assessment.

The climate analysis involved data preparation and data analysis. The data preparation focused on the selection of relevant climate parameters and thresholds that could have an impact on Alectra's distribution system (e.g., temperatures, precipitation, wind, and extreme events). The data analysis focused on the selection of climate scenarios to determine climate projections. Where possible, climate projections were made on a grid cell that covers a region of the earth, encompassing an area of 10 km x 6 km (Figure 1-1). Additional sources referenced to establish the projected climate conditions included historical observed climate data and literature review using specialized datasets. The results of the climate analysis were leveraged to determine the probability of a weather event or climate trend occurring in a specific area. A detailed description of the climate data analysis is presented in Section 2.

Similar to the climate analysis, the outage data analysis also involved data preparation and analysis. The data preparation focused on the review of relevant Alectra information (i.e., outage records) and historical weather data, and the data analysis focused on single and multi-variable analysis methods to quantify the impacts of weather events through the development of the dependent parameters, or "predictors". A predictor contains various weather value levels (e.g., maximum gust speed) and associated CI based on the historical data clustering analysis. Approximations were made to supplement the outage data analysis in cases where outage or weather data was limited. These approximations took into consideration differences in asset class distribution, as summarized in Table 1-1 below.

Table 1-1: Classification of Overhead and Non-Overhead Assets

Overhead	Non-Overhead
Wood and Concrete Poles	Switchgear
Overhead Switches	Underground Cables
Overhead Conductors	Transformers[3]

The results of the outage data analysis (predictors) and the approximations were used to determine the severity of the impact of each climate parameter on Alectra's distribution system. A detailed description of the outage data analysis is presented in Section 3.

The CI value is a statistical estimation (not a precise quantitative CI impact calculation) of potential CI ranges for consequence benchmarking based on historical incidents. Climate parameters like wind speed, temperature, and precipitation are the independent parameters, whereas the resulting CI is the dependent variable of the climate parameters. For the purpose of this Study, the severity of weather events used in the risk assessment analysis was entirely based on associated CI values, and it did not include any maintenance effort or capital outlay.

The results of the climate analysis (i.e., the probability of a weather event or climate trend occurring in a specific area) were coupled with the outage data analysis (severity of the impact of

[3] Outage records provided details about failed equipment types; however, some asset classes could not be further broken down into sub-classes. For example, all transformers (pole mount, pad-mount, submersible, and vault) were treated as a single asset class in this study.

a climate parameter on Alectra’s distribution system) to generate the risk profiles for Alectra’s service zones. A detailed description of the risk assessment methodology is presented in Section 4.

The analysis consisted of the following two (2) levels: Service Zone Level and Grid Cell Level. Due to outage records data limitations, it was not possible to further examine at the Asset Class Level, and the risk profiles have been developed for specific service zones as opposed to specific asset classes. The levels of analysis are presented in Figure 1-2. As the analysis progressed through these levels, the results provided increasing granularity with respect to impacts of the climate parameters. The Asset Class Level analysis was leveraged for some approximations, which are detailed in Section 3.3.

Figure 1-2: Levels of Analysis

2. Climate Analysis

The climate data analysis involved five (5) major activities:

- Identification of climate parameters and thresholds.
- Selection of IPCC climate scenarios.
- Estimation of the historical and projected climate conditions.
- Determination of the occurrence of climate parameters.
- Conversion of probabilities into a standardized scoring system to support the risk assessment.

2.1 Climate Parameters and Thresholds

For this Study, publicly available information was used to define climate parameters and thresholds. This information was obtained from different sources including ClimateData.ca, IPCC atlas, and literature review, including grey literature[4].

ClimateData.ca[5] publishes projections for 36 different variables. The output values measure singular extreme temperatures, sequential or annual maximum number of days with temperatures above or below a certain threshold, certain variables specifically linked to agricultural production, total annual precipitation, maximum precipitation for a certain number of days, sequential or annual maximum number of days with precipitation above certain threshold, number of days without precipitation, and some specific variables such as freeze-thaw cycles days and days with specific humidity thresholds.

The identification of relevant climate parameters and specific power distribution infrastructure impact thresholds was an iterative process involving literature review and consultations with Hatch Subject-Matter Experts (SMEs). Nine (9) climate parameters covering temperature, precipitation, freeze- thaw cycles, wind, lightning, and extreme event hazards were identified as relevant to Alectra's distribution system. In some cases, multiple thresholds were developed for the same parameter, as they demonstrated higher significance based on historical CI for one or more of the service zones within Alectra's distribution system.

Table 2-2 summarizes the results of the literature review conducted to identify relevant climate parameters and thresholds.

[4] Grey literature refers to literature that has not been produced through traditional publishing and distribution channels, such as reports, policy literature, newsletters, government documents, etc.
[5] ClimateData.ca is a collaboration between Environment and Climate Change Canada (ECCC), the Computer Research Institute of Montréal (CRIM), CLIMAtlantic, Ouranos, the Pacific Climate Impacts Consortium (PCIC), the Prairie Climate Centre (PCC), and HabitatSeven. ClimateData.ca is a publicly available online portal that enables access to future climate projections and historical data.

Table 2-1: Climate Parameters and Thresholds

Climate Parameter	Threshold	Climate Parameter
High Temperature	Number of days with a maximum temperature greater than: • 32°C • 40°C	• Equipment may be unable to cool properly, reducing functionality.
Low Temperature	Number of days with a minimum temperature less than: • -25°C	• Underperformance of vehicles and outdoor infrastructure.
Heat Waves	Number of days in a heat wave, defined as >=3 consecutive days when maximum temperature greater than: • 32°C • 40°C	• System overloading due to high demands on electrical grid by increased air conditioning. • Equipment may be unable to cool properly, reducing functionality.
Cold Waves	Number of days in a cold spell, defined as >=3 consecutive days with mean daily temperature less than: • 20°C.	• System overloading due to high demands on electrical grid by increased heating use.
Precipitation (Rain/Snow)	The number of wet days, defined as days with precipitation above: • 20mm • 50mm	• Low-lying equipment (e.g., vaults, UG cables) may be more vulnerable to flooding. • Extreme precipitation can result in reduced accessibility to assets (e.g., flooded roadways).
Freeze-Thaw Cycles	Number of days when the daily maximum temperature is higher than 0°C and the daily minimum temperature is less than or equal to -1°C.	• Thermal stresses and increased weathering and damage (cracking and fissuring in materials), potentially concrete as well. • Frost may cause the displacement of the ground (frost heave) and compromise the stability of assets.
Wind	Wind gusts of: • Less than 60 km/h[6] • 61 to 80 km/h • 81 to 100 km/h • 101 to 120 km/h • Greater than 120 km/h	• Potential damage due to structural member overload, tree/limb falls, and wind-swept debris. • Reduced access due to debris deposits. • Circuit breakers and switchgear cause secondary impact when a primary asset that is downstream fails.
Lightning	• Number of cloud-to-ground lighting flashes	• Lightning strikes may trip a breaker, short circuit fuses and arresters.
Extreme Events	• Tornadoes • Derechos • Ice Storms	• Potential for significant system structural damages. • Tree/limb falls and flying debris. Debris could directly contact and damage assets or disrupt of transportation corridors (affecting the response efforts). • Ice accumulation on tree branches and resulting breaks; combined ice accretion and wind is a concern.

[6]ECCC station data records provide limited details regarding exact observed values of select parameters, particularly for maximum wind gust speeds below 30 km/h. The outage clustering analysis considered wind gusts below 60 km/h as a single threshold due to limited granularity, although several of these events may have occurred when wind gusts were closer to 60 km/h.

Of the nine (9) climate parameters identified in Table 2-1, five parameters (low temperature, heat waves, cold waves, freeze-thaw cycles, and lightning) were not carried forward in the risk assessment due to limited data availability or relatively low correlation to CI. Therefore, the four climate parameters used in this Study are high temperatures, precipitation, wind, and extreme events (tornadoes, derechos, and ice storms).

2.2 Climate Scenarios

The climate scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) have long been used to investigate future vulnerability to climate change and assess the resiliency of strategic plans.

The Coupled Model Intercomparison Project (CMIP) has become one of the foundational elements of climate science by coordinating the design and distribution of global climate model simulations of past, current, and future climate. The IPCC sixth assessment report (AR6) features new state-of-the-art CMIP6 models.

CMIP6 includes over 100 models from more than 50 modelling centers. By combining many different models and thus forming an 'ensemble', scientists can extract information about the full range of possible future climate changes and the associated uncertainties.

The latest iteration of scenarios used in the IPCC AR6 report are based on a set of Shared Socio-economic Pathways (SSPs). The SSP-based scenarios combine future societal development with the Representative Concentration Pathways (RCPs), which describe plausible future climate scenarios based on future greenhouse gas concentrations and different pollutants caused by human activities[7].

Five SSPs were created (labelled SSP1 through SSP5), with varying assumptions about human developments including: population, education, urbanization, gross domestic product (GDP), economic growth, rate of technological developments, greenhouse gas (GHG) and aerosol emissions, energy supply and demand, land-use changes, etc.

As previously mentioned, SSPs were designed to function in combination with a new and improved version of RCPs. Not all possible combinations of SSPs and forcing scenarios are viable and therefore, some do not have simulations[7]. Possible combinations include[8]:

- SSP1-1.9: very ambitious scenario to represent a pathway that enables society to reach the 2015 Paris Agreement target of keeping global warming well below 2°C (and pursuing efforts to limit warming to 1.5°C), compared to pre-industrial levels.
- SSP1-2.6: sustainable development scenario.
- SSP2-4.5: intermediate scenario.

[7] CMIP6 and Shared Socio-economic Pathways overview (canada.ca)
[8] In the SSP labels, the first number refers to the assumed shared socio-economic pathway, and the second refers to the approximate global effective radiative forcing in W/m^2 by the year 2100.

- SSP3-7.0: regional rivalry scenario.
- SSP5-8.5: fossil-fuel based development.

Climate scenarios SSP1-2.6, SSP2-4.5 and SSP5-8.5 were selected for this Study as they span a wide range of possible future climates, have associated projections available from many different climate models, and have levels of Radiative Forcing that correspond with the three RCPs (high or RCP8.5, medium or RCP4.5 and low or RCP2.6). Where possible, these climate scenarios were used to obtain the historical and projected climate conditions, as described in Section 2.3.

2.3 Historical and Projected Climate Conditions

2.3.1 Historical Climate Data

The baseline climate for the period refers to the historical conditions. The period from 1950 to 2020 was selected as the baseline for this Study.

Climate parameters for the baseline were established using information from the following sources:

- Modelled historical data obtained from climatedata.ca[9].
- Historical climate data obtained from Environment and Climate Change Canada (ECCC)[10].
- Specialized climate studies (literature review).

The baseline climate data associated with temperature and precipitation were based on modelled historical data, which is produced using global climate models (GCMs).

ClimateData.ca provides historical climate simulations from 24 climate models[9]. Modelled historical data is simulated data with daily, monthly, and annual average and individual values, potentially slightly different from those observed in the historical dataset. Since models and meteorological observations do not generally represent information at the same spatial scales, it is standard practice to use modelled historical data when making direct comparisons with modelled future data[9].

Climate projection results are reported using a grid that covers a specific region of the Earth. Each grid cell encompasses an area, such that the climate data for the grid cell is an estimate of the climate data for every point in the grid cell. Discrete model "cells" represent computational units of a climate model. The simplest model grids typically divide the globe (or model domain) into constant angular grid spacing (i.e. a latitude/longitude grid). A climate model's horizontal resolution is often expressed as the size of a single grid cell[9].

[9] Home — ClimateData.ca
[10] Historical Data - Climate - Environment and Climate Change Canada (weather.gc.ca)

Since wind speed data is not available on ClimateData.ca, wind speed was sourced from ECCC[10]. ECCC has a network of more than 1000 weather stations across the country with hourly observations. Some of these stations have been in operation for more than 30 years.

Extreme events (e.g., tornadoes, derechos, and ice storms) are not available in climate models. In these cases, specialized studies (e.g., the historical tornado database) were consulted to establish the baseline climate.

2.3.2 Future Climate Data

Climate projections were developed for the period ranging from 2021 to 2075, for each of the identified climate parameter thresholds.

Climate projections were based on outputs from ClimateData.ca, which provides climate projections using the Coupled Model Intercomparison Project (CMIP6), the most current global climate model data now available. CMIP6 data has been downscaled and bias-adjusted using the BCCAQv2 method[11].

ClimateData.ca provides climate simulations from 24 climate models. The use of multiple models to generate a 'best estimate' of climate change (multi-model ensembles) is preferred over a single or few individual model outcomes, as each model could contain inherent biases and weaknesses, and constructing multi-model ensembles can reduce and inform on the uncertainties in the climate projections[11].

Climate projection data for the wind speeds were obtained from the IPCC atlas.[12,13] The data retrieved through this atlas is also an output from the CIMP6, but at the Eastern North American regional scale. A filter was applied to export climate data on land only, excluding the projections for coastal and mountainous regions.

2.4 Frequency of Occurrence of Climate Parameters

The annual frequencies estimated for each Alectra location were calculated for different study periods including Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075).

The average annual frequency for each climate parameter for each study period represents the total number of days (temperature and precipitation), hours (wind) or number of events (tornadoes, derechos and ice storms) with the climate parameters greater than` the specified threshold (Table 2-1) divided by the study period (e.g., 71 years for the baseline). For example, the parameter temperature above 32°C was exceeded between 371 and 845 times during the study period, in the Alectra service zones. Therefore, by dividing the number of exceedances (between 371 and 845 times) by the study period (71 years), the average annual frequency was calculated between 5 days per year and 12 days per year.

[11] Home — ClimateData.ca
[12] GitHub - IPCC-WG1/Atlas: Repository supporting the implementation of FAIR principles in the IPCC-WGI Atlas
[13] IPCC WGI Interactive Atlas

Table 2-2 provides a summary of the projected climate change for the Study Period (2021-2075) based on data provided on climatedata.ca for all Alectra locations. The numbers in the parenthesis represent the minimum and maximum frequency for all Alectra locations.

Table 2-3 provides a summary of extreme events for the study period, based on literature review. The numbers in the table represent the average number of events per year for all Alectra locations.

A detailed description of the climate data and analysis used for this Study is presented in Appendix A.

Table 2-2: Projected Climate Parameters Change for the Study Period (2021- 2075), for all Alectra locations

Climate Parameter	Unit (per year)	Baseline (1950-2020)	Study Period (2021-2075)			Trend in Frequency
			SSP1-2.6	SSP2-4.5	SSP2-8.5	
Temperature above 32°C	Days	[5, 12]	[21, 32]	[26, 37]	[36, 49]	↑
Temperature above 40°C	Days	[0, 0]	[0, 0]	[0, 1]	[1, 2]	↑
Precipitation above 20mm	Days	[1, 1]	[1, 1]	[1, 1]	[1, 1]	Stable
Precipitation above 50mm	Days	[9, 11]	[10, 13]	[10, 13]	[11, 13]	↑
Wind Gust Below 60 km/h	Hours	[347, 361]	[347, 361]	[347, 361]	[346, 361]	Stable
Wind Gust Between 61 and 80 km/h	Hours	[1, 16]	[1, 16]	[1, 16]	[1, 17]	↑
Wind Gust Between 81 and 100 km/h	Hours	[0, 2]	[0, 2]	[0, 2]	[0, 2]	Stable
Wind Gust Between 101 and 120 km/h	Hours	[0, 0]	[0, 0]	[0, 0]	[0, 0]	Stable
Wind Gust Over 121 km/h	Hours	[7, 12]	[25, 32]	[30, 37]	[42, 49]	↑

Table 2-3: Projected Extreme Events per Year for the Study Period (2021- 2075), for all Alectra locations

Climate Parameter	Unit (per year)	Baseline (1950-2020)	Study Period (2021-2075)	Trend in Frequency
Tornadoes	Events	1.5	2.8	↑
Derechos	Events	0.05	0.25	↑
Ice Storms	Events	0.34	0.34	Stable

2.5 Standardized Probability Scoring

The annual probability of occurrences for climate parameters (as described in Section 2.4) were converted into standardized probability scores to support the risk assessment.

The probability scoring for this Study ranges from 1 to 5. The frequency of occurrence was based on Alectra's Enterprise Risk Management (ERM) framework, while the name/descriptors of the probability scores were adjusted to better define the scores. The probability scoring system used for this Study is presented in

Table **2-4**.

Table 2-4: Probability Scoring

Probability Score	Frequency
1 (Unlikely)	Not occurred previously at Alectra and is extremely rare in the Utility industry (once every 20-25 years)
2 (Somewhat Unlikely)	Not occurred previously at Alectra and has infrequently occurred in the Utility industry (once every 10-20 years)
3 (Likely)	Has occurred at Alectra and periodically in the Utility industry (once every 5-10 years)
4 (Very Likely)	Has occurred at Alectra and frequently to many organizations in the Utility industry (once every 5 years)
5 (Almost Certain)	Has occurred at Alectra regularly and to almost all organizations in the Utility industry (at least once a year)

For example, the annual probability of high temperatures above 40°C under SSP5-8.5 occurring was estimated to be, on average, 0.01 times per year during the historical period, or once in one hundred years. Therefore, the probability scoring for high temperatures above 40°C was estimated to be 1 (Unlikely). Similarly, the annual probability of high temperatures above 32°C occurring was estimated to be, on average, 9.88 days per year during the historical period. Therefore, the probability scoring for high temperatures above 32°C was estimated to be 5 (Almost Certain).

In the case of tornadoes, the probability scoring was estimated by considering the proximity of the area to the tornado alley. The tornado alley is a geographical location where tornadoes are most frequent. Although there are no definitively set boundaries of tornado alley, the tornado alley in Ontario expands through Southern Ontario and Quebec, especially in the region between the Great Lakes. Figure 2-1 represents all confirmed and probable tornados in Canada from 1980 to 2009, while Figure 2-2 provides a closer look at the tornados registered in Ontario.

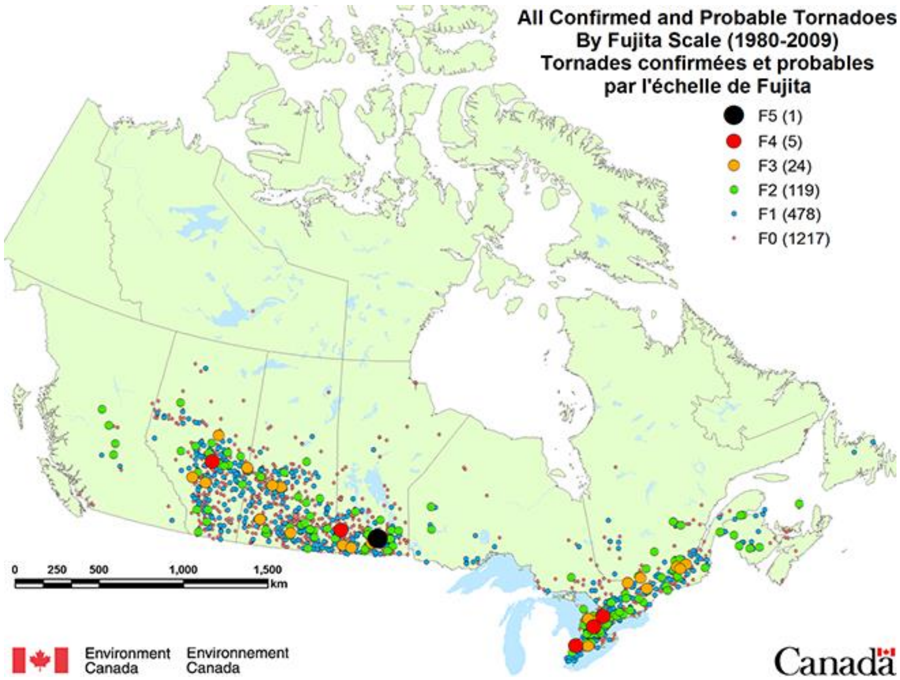


Figure 2-1: Confirmed and Probable Tornadoes in Canada (1980-2009)

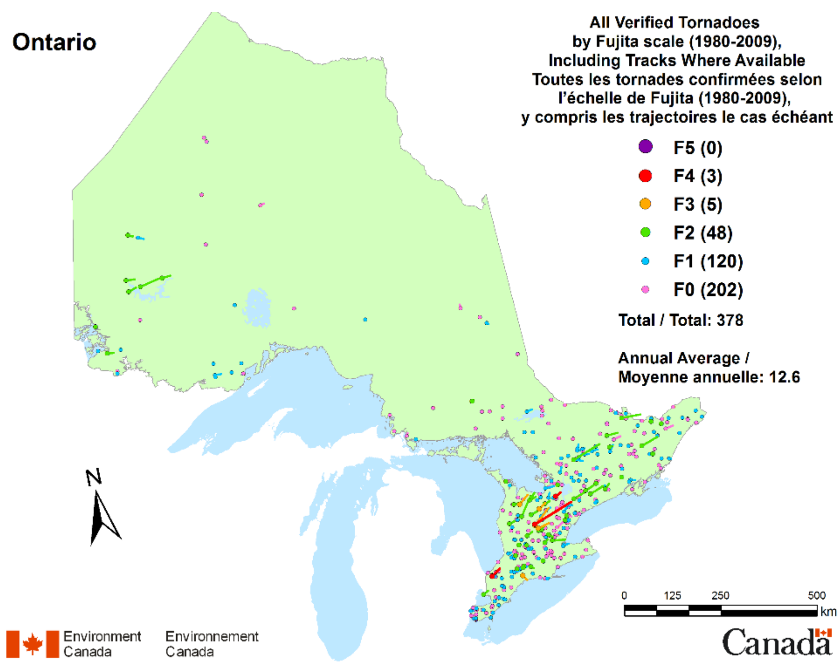


Figure 2-2: Confirmed and Probable Tornadoes in Ontario (1980-2009)

Areas within the tornado alley were deemed likely (i.e., a score of 3) or very likely (i.e., a score of 4) to see a tornado. The probability scoring for areas within the tornado alley[14] was determined based on the probability of occurrence as defined in Section 2.4. Areas that did not fall directly within tornado alley (but in close proximity) to the tornado alley[15] were deemed less likely to see a tornado than areas within the tornado alley, and therefore the probability scoring was set to a score of 2 (Somewhat Unlikely). Similarly, the probability scoring for areas further away from the tornado alley[16] was set to a score of 1 (Unlikely).

The estimated probability scores for each Alectra location, for each climate variable, and for different time horizons are presented in Appendix C and Appendix D.

3. Outage Data Analysis

3.1 Data Preparation

3.1.1 Data Selection

The outage data analyses were based on historical sustained outages classified by Alectra as "weather-related", historical sustained outages caused by tree contact driven by weather events, and Major Event Days (MEDs).[17] Momentary outages have been excluded from the analysis. The analysis used available outage data from 2016-2023.

3.1.2 Data Harmonization

The data validation process was completed prior to statistical modelling and correlational analysis of the weather parameters and outage events to ensure sufficient data population. Throughout the data analysis, data cleansing was performed to remove outliers that could potentially skew the analysis results. While extreme events and outliers are possible, the clustering exercise was focused on more frequent occurrences of weather events, where "clusters" of data points could be found (see Section 3.2). The approach leveraged to determine impacts for higher thresholds of the climate parameters and impacts for extreme events is presented in Section 3.3.3.

3.1.3 Climate Parameter Determination

The following climate parameters were selected for the outage analysis: maximum wind gust speed (km/h), total precipitation (mm), and minimum and/or maximum temperature (°C) observed on any given day. These parameters were chosen based on data availability and to align with climate projections.

3.2 Outage Clustering Analysis

3.2.1 Clustering Methodologies

[14] Areas within the tornado alley include Penetanguishene, Barrie, Alliston-Thornton, Tottenham-Beeton, Bradford, and Aurora.
[15] Areas in close proximity to tornado alley include Markham, Richmond Hill, Vaughan, Brampton and Mississauga.
[16] Areas outside of the tornado alley include Guelph-Rockwood, Hamilton and St. Catharines.
[17] Hatch was advised Alectra's definition is aligned with OEB definition for Major Event Days. The classification of Major Event Days and weather-related outages was assessed prior to the analysis and is defined by Alectra's outage records.

The outage analysis employed clustering methodologies to determine correlations between historical outage events and related weather events. A "cluster" refers to a group of data points that share some common characteristics[18], and clustering approaches can be used to understand commonalities within subsets of data. A centroid is the center point of the cluster, representing the average of all the data points that fall within the cluster[19]. Several methodologies were tested before selecting the appropriate one for each dataset. The following are the three key methodologies leveraged for the clustering analysis:

- **Simple K-Means Algorithm:** an unsupervised, centroid-based machine learning algorithm. Simple K-Means splits the dataset into a select number of groups based on respective distances to the centroids. The data points are placed in specific clusters based on the minimum distance to the cluster's centroid relative to all the other centroids[20].
- **Expectation-Maximization (EM) Algorithm:** a distribution-based clustering algorithm. EM passes the data through iterations that alternate between two steps: Expectation (E) and Maximization (M). For each data point, the probability that it would be grouped with each cluster, or the expected log-likelihood[21], is calculated using current parameters ("E" - step). The parameters are then re-estimated for each cluster to increase the probabilities ("M-step")[22]. The algorithm provides another way to segment the data into smaller subsets with some commonalities.
- **Canopy Algorithm:** This algorithm is a clustering approach that uses approximate measures of distance to group data into "canopies", which are clusters of data points that can sometimes overlap. Each canopy represents a subset of data points that fall within a specific distance from the center of the canopy. The algorithm assigns each data point to a canopy, with some data points assigned to multiple canopies[23].

As mentioned above, these unsupervised machine learning algorithms can help ascertain trends and indicate that certain observations in a dataset have similar qualities. Several simulations were conducted for each dataset to determine the most appropriate methodology for that subset. The criteria used to select the appropriate clustering result included the number of clusters, cluster sample percentages, and granularity of the cluster's centroid values generated for each cluster. These criteria remained consistent across all datasets.

3.2.2 Outage Clustering Analysis Procedure

Initially, a preliminary single-variable correlation analysis was conducted to understand the dominant climate parameters. Once the key climate parameters had been identified, the datasets

[18] Data clustering: application and trends | Artificial Intelligence Review
[19] Cluster Centroid - an overview | ScienceDirect Topics
[20] Stanford CS221
[21] A review of the Expectation Maximization algorithm in data-driven process identification - ScienceDirect
[22] EM Clustering Approach for Multi-Dimensional Analysis of Big Data Set
[23] canopy.dvi

with sufficient population were considered for the clustering analysis. The clustering analysis procedure is shown in Figure 3-1 below.

Figure 3-1: Single and Multivariable Analysis Clustering Procedure

The clustering included both single and multivariable analyses to assess the climate parameters individually, and in combination with each other. The results of the single variable analysis were used to create predictors for each service zone and climate parameter. The multivariable analysis was leveraged to validate the predictors while considering all climate parameters simultaneously. The single variable analysis is advantageous at capturing outage events and analyzing CI caused by a single climate parameter, such as high winds. However, an outage caused by a weather event with multiple attributes (e.g., ice storm) can consist of high winds, low temperature, and precipitation. The combination of all these climate parameters can result in significantly higher consequence (CI), captured by the multivariable analysis. Hatch Subject-Matter Expert (SME) validation was conducted during both the single and multivariable analysis steps to assess the reasonableness of the statistical analysis results and overall findings.

This analysis procedure was executed for all service zones and grid cells where sufficient data was available. For service zones with insufficient data, informed approximations were made to estimate impacts. For a detailed description of the approximation methodology, see Section 3.3.2.

3.2.3 Predictor Results

The predictors can be used to determine the impact of the occurrence of each climate parameter threshold for the specific service zone, based on historical outage information. The predictor helps identify what the impact (in CI) would be for the specific climate parameter thresholds. Predictors were established using several clustering methodologies to ascertain commonalities in each subset of data, through single variable and multivariable analysis. The results of the clustering analysis were data-driven predictors for each climate parameter that were used to estimate future impact. Predictors were developed at the Service Zone Level and the Grid Cell level, where sufficient data was available.

For service zones where sufficient data was not available to create strong predictors, an approximation approach was utilized to determine impacts, as detailed in Section 3.3.2.

3.3 Standardization and Approximations

3.3.1 *Standardization*

Each subset of data that the clustering was performed on was used to develop predictors unique to that subset, and the resulting climate parameter thresholds were not consistent across the different service zones and grid cells. Climate projections, however, have uniform thresholds across all service zones for each climate parameter. Through extrapolation and application of engineering judgement, the climate parameter thresholds were standardized for each climate parameter across all service zones to align the results with the climate projections and generate risk profiles.

3.3.2 *Approximations*

Selected regions had limited historical outage and weather data, and predictors could not be developed for the climate parameters. Data limitations include small population size, a homogeneous dataset, or a dataset that does not follow a normal distribution. Consequently, an informed approximation approach was utilized to complete the analysis and generate cohesive risk profiles that span all of Alectra’s service zones. Informed approximations, coupled with engineering judgement, were made to estimate the impact for the following two scenarios at the Service Zone Level: service zones with no predictors, and service zones without predictors for certain climate parameters. The predictors that had been developed for service zones with sufficient data were scaled to approximate the impact in neighboring areas without predictors. The approximations took into consideration the differences in asset distribution (i.e., overhead system vs non-overhead system), geographical considerations that could impact weather patterns (e.g., proximity to bodies of water), and observed impacts on overhead and non-overhead assets in outage records.

The approximations assumed that similarity of characteristics of the grid (i.e., response functionality) can be inherited by neighboring areas (e.g., asset demographics including physical attributes, operation after installation, etc.). Because the predictors were not meant to be quantitatively precise due to limited data quality and the nature of probability, but rather a qualitative indication for cross-domain and asset cost benchmarking for decision making, the approximations have been assumed to be sufficient for comparative purposes.

Additionally, as high thresholds of climate parameters have not yet been observed in Alectra’s service territory, several statistical approaches were tested to estimate these impacts. Due to limited available information, the modelling results were deemed unreliable for the high thresholds. As a result, the analysis relied on engineering judgement based on studies of similar nature, internal SME knowledge, and domain expertise to estimate appropriate impacts for high thresholds of precipitation and temperature that have not yet been observed through historical events.

Considering the Grid Cell Level analysis provided a more granular view of the Service Zone Level analysis, and all grid cells have been captured through the respective service zones, the approximations were only applied at the Service Zone Level.

3.3.3 Extreme Events

Future projections and climate studies predict increasing severity of climate change, leading to a projected increase in the frequency of extreme weather events (i.e., tornadoes, derechos, and ice storms). Due to the low frequency of such events observed through historical outage events, data was not available for detailed modelling and alternative approaches were leveraged to determine these impacts and accurately forecast future risks. Literature review was conducted to estimate the impacts for such events based on available information across geographic locations similar to Alectra's service territory where these events have occurred in the past.

3.4 Key Assumptions

Outage Type and Data: All analyses were based on the sustained outages identified as weather-related or caused by tree contact, and MED. Momentary outages have been excluded from the analysis. The analysis uses available outage data for the last 7 years.

Outage Attributes Continuity: Total number of Customers Interrupted in historical outages and distribution ratio by asset class was assumed to be representative of future outages.

Customer (Interrupted) Count, Outage Count: It was assumed to be accurate.

Weather Event Impact: All outages that occurred on the same day in the same service zone and/or grid cell were assumed to be caused by the same weather event for both the Service-Zone Level analysis and the Grid Cell Level analysis. The sum of total Customers Interrupted in those areas on those days was considered to capture the total impact of the weather event.

CI vs Customer Minutes Outage (CMO): CI was the only parameter used to assess the impact of the weather events on Alectra's distribution network. Outage duration and CMO were excluded from the analysis with the consideration that restoration steps are impacted by external factors such as manual restoration steps, topology, distance travelled, urban versus rural areas, operations of the utility, etc.

Outage Data Availability: Information regarding the types of equipment that failed or were interrupted was not readily accessible in the outage records. Consequently, a manual examination of outage data was performed, during which assumptions were made to identify the failed equipment. The precision of this identification relies on the level of detail and accuracy contained within the outage's commentary.

Weather Data Availability: ECCC stations were used to correlate climate parameters to outages. Weather data records for the selected parameters were assumed to be accurate. Select stations have limited data availability and may not capture the intensity of weather events in the service zone if an incident does not take place near the ECCC station.

Predictor Accuracy: The project team utilized K-Means, EM, and Canopy algorithms for data analysis and building predictors. The resulting predictors provide insightful clustering relationships between climate parameters and customer interruption. However, the accuracy of the predictors was limited to the quality of the input data. The predictors were not meant to be quantitatively precise due to limited data quality of weather data[24], outage data, and the nature of probability, but rather a qualitative indication for cross-domain decision making.

Granularity of Precipitation Projections: Historical weather data from ECCC stations provide granularity for climate parameters such as rain and snow for certain areas, enabling correlational analysis for each parameter. The publicly available climate models only provide projections for total precipitation. This indicator describes the total amount of precipitation (rain and snow combined) that falls within the selected period. Predictors for total precipitation have been used to combine the consequences with the projections.

Asset Degradation: As mentioned in Section 1, the objective of this Study is to understand the vulnerability of Alectra's distribution system to evolving weather patterns as a result of climate change. The outage analysis was conducted to understand the correlation between the selected climate parameters and CI impact. It is recognized that additional factors may impact CI, including asset health, standard operating procedures (SOPs), and asset degradation. This study is focused on correlations between outages and weather parameters, and does not include allowances to consider maintenance effort, capital outlays, and asset degradation.

4. Risk Assessment

The vulnerability of the infrastructure components to climate parameters was determined by employing a screening level risk-based methodology (risk assessment). In the risk-based methodology, the probability of the occurrence of a climate parameter was coupled with the severity of the impact on the system:

$$Risk\ Rating = Probability\ (P)\ x\ Severity\ (S)$$

The probability (likelihood) score represented the likelihood of the occurrence of a climate event above the selected threshold (Section 2.5). The severity (consequence) score was used to determine a range of CI, should the climate event occur (Section 3).

The severity scoring system used for this Study ranges from 1 to 5 and was developed based on the results of the CI analysis, as presented in Table 4-1.

Table 4-1: Severity Score

Severity Score	CI Range
1	<1,500
2	1,500 – 4,000
3	4,000 – 20,000
4	20,000 – 80,000
5	>80,000

[24] Climate data extraction tool - Daily climate data (canada.ca)

Combining the severity ratings of 1 to 5 and probability ratings of 1 to 5 produced a 5 x 5 risk matrix score, ranging from 1 to 25, as shown in

Table 4-2. Risks have been classified as very high, high, moderate, low, and very low, as presented in Table 4-3.

Table 4-2: Risk Matrix

Severity	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

Table 4-3: Risk Classification

Risk Rating	Range
Very Low	<3
Low	4 – 6
Moderate	7 – 10
High	11 – 16
Very High	>17

5. Findings

5.1 Risk Assessment Results

Several climate parameters and thresholds were selected for this assessment to represent limits beyond which a climate event can have an adverse impact on specific infrastructure within Alectra's distribution system.

For the purpose of this Study, the severity of a climate event affecting Alectra's distribution system was based on the total CI. Therefore, heavily populated areas have higher consequences for the same climate event than areas with a smaller number of customers. Other parameters that could influence prioritization for hardening the grid (e.g., capital expenditure, reputational losses, etc.) were not included as part of this Study.

A risk heat map summary for the baseline (1950-2020) and the study period (2021-2075) is presented in Table 5-1 to Table 5-5. The colors in each table represent the risk classification as provided in Table 4-3. Detailed risk profiles for each Alectra location and for different study periods are presented in Appendix C.

Table 5-1: Risk Heat Map Summary, Temperature

Alectra Location	T_{max} above 32°C		T_{max} above 40°C	
	Baseline	Study Period	Baseline	Study Period
Penetanguishene				
Barrie				
Alliston-Thornton				
Tottenham-Beeton				
Bradford				
Aurora				
Markham				
Richmond Hill				
Vaughan				
Brampton				
Mississauga				
Guelph-Rockwood				
Hamilton				
St. Catharines				

Table 5-2: Risk Heat Map Summary, Wind Gusts Below 100 km/h

Alectra Location	Wind Gust Below 60 km/h		Wind Gust between 61 and 80 km/h		Wind Gust between 81 and 100 km/h	
	Baseline	Study Period	Baseline	Study Period	Baseline	Study Period
Penetanguishene						
Barrie						
Alliston-Thornton						
Tottenham-Beeton						
Bradford						
Aurora						
Markham						
Richmond Hill						
Vaughan						
Brampton						
Mississauga						
Guelph-Rockwood						
Hamilton						
St. Catharines						

Table 5-3: Risk Heat Map Summary, Wind Gusts above 100 km/h

Alectra Location	Wind Gust between 101 and 120 km/h		Wind Gust above 120 km/h	
	Baseline	Study Period	Baseline	Study Period
Penetanguishene				
Barrie				
Alliston-Thornton				
Tottenham-Beeton				
Bradford				
Aurora				
Markham				
Richmond Hill				
Vaughan				
Brampton				
Mississauga				
Guelph-Rockwood				
Hamilton				
St. Catharines				

Table 5-4: Risk Heat Map Summary, Precipitation

Alectra Location	Precipitation above 20 mm		Precipitation above 50 mm	
	Baseline	Study Period	Baseline	Study Period
Penetanguishene				
Barrie				
Alliston-Thornton				
Tottenham-Beeton				
Bradford				
Aurora				
Markham				
Richmond Hill				
Vaughan				
Brampton				
Mississauga				
Guelph-Rockwood				
Hamilton				
St. Catharines				

Table 5-5: Risk Heat Map Summary, Extreme Events

Alectra Location	Tornados		Derechos		Ice Storms	
	Baseline	Study Period	Baseline	Study Period	Baseline	Study Period
Penetanguishene						
Barrie						
Alliston-Thornton						
Tottenham-Beeton						
Bradford						
Aurora						
Markham						
Richmond Hill						
Vaughan						
Brampton						
Mississauga						
Guelph-Rockwood						
Hamilton						
St. Catharines						

5.2 Potential Adaptation Strategies:

A potential list of adaptation strategies that may be available to address the potential impacts of evolving weather patterns resulting from climate change is presented in Table 5-6.

It is important to note that these measures have not been assessed relative to Alectra's operation, design, current planning or business functions, as such assessments are outside the scope of this Study.

Table 5-6. Potential Adaptation Strategies Based on Climate Parameters

Potential Adaptation Strategies	Climate Parameter			
	Temperature	Precipitation	Wind Gusts	Extreme Events
Enhancing grid flexibility and redundancy allows the grid to better withstand and quickly recover from disruptions in areas with capacity constraints. Adequate capacity (e.g. DER) allows for continued service when demand is high.	✓			
Upgrading to higher-class poles and infrastructure can enhance system resilience. Alectra could benefit from changing design basis.		✓	✓	✓
Converting overhead lines to underground systems can significantly reduce their vulnerability to damage from ice storms and falling trees.			✓	✓
Investment in weather forecasting and modeling can provide advanced warning of extreme weather events, allowing for better positioning of crews and equipment.	✓	✓	✓	✓
Elevating equipment or relocating substation(s) to a non-flood zone to reduce the risk of flooding. Building flood control means (improving storm sewer system) to divert water away from substation.		✓		
Enhanced vegetation management programs for power lines can prevent outages caused by vegetation contacting lines during high winds and storms.			✓	✓
A more detailed assessment of structural resilience of strategic assets may be considered and the adaptation measures studied and prioritized.			✓	✓

6. Next Steps and Future Recommendations

Reflecting on the findings of this Study, some approaches that could be taken to enhance the resilience of Alectra's distribution system and better protect against severe weather events and changing climate trends include the following:

- Consider the results of this Study when updating investment plans with adaptation measures to reduce identified risks (e.g., capital investments, enhanced maintenance procedures, etc.).
- Develop a plan to enhance the resiliency and capability of the existing distribution network to withstand severe weather events through proactive upgrades.
- Update and/or change the standards being used to better reflect the current and future risks being identified for new installations and/or maintenance testing activities.
- Conduct another assessment once more data becomes available (e.g., in 5 years) to enhance the understanding of the system's vulnerability to climate change at an individual asset level. More detailed and extensive outage records, considerations for specific electrical configuration and area characteristics in addition to CI, and detailed climate modelling are all examples of information that could further refine the analysis results.

The objective of this Study was to assess the vulnerability of Alectra's distribution system to climate change. This was achieved through the development of risk profiles for each location that can help identify trends observed through historical outages and weather events. To further enhance understanding of the risks and vulnerabilities within the distribution system, future assessments and adaptation plans could take into consideration the following items:

- Continuous, prolonged weather events that occur over several days (e.g., heat waves) and the potential impacts of the extended weather event duration on Alectra's system. When designing climate risk and mitigation plans, Alectra could look for ways to bring the duration of outages, particularly those associated with extreme, acute events, into the analysis.
- Critical loads (e.g., hospitals) need to be served by distribution assets with very high reliability to reduce outage risks due to climate change, in addition to other risk factors. Alectra could work collaboratively with communities to identify critical infrastructure and develop a plan for climate resiliency. If critical loads are identified, particular attention could be paid to adapt system assets in each location where such critical loads are located, reducing the risk of severe impacts from climate change events.
- Customers in service zones with small customer numbers do not have high ratings on the CI-based severity scale. To account for risks in areas with fewer customers, these areas could be considered as a group in terms of climate risk mitigation action plans. Future studies could take into consideration additional metrics to further enhance the granularity of

the risk assessment results. Additionally, with the development and population growth of these service zones, the number of customers will increase, inherently increasing the number of CI values and risk profiles in case of future climate-related events.

Appendix A
Climate Data and Analysis

A.1 High Temperature

High temperatures were evaluated by calculating the number of days per year with the respective temperature parameter exceeding the selected threshold. Temperature thresholds for this Study were selected as 32°C and 40°C, as described in Section 2.1

The annual frequencies estimated for each Alectra location were calculated for different time horizons including Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075). Historical and projected climate conditions for the different time horizons were based on data obtained from climatedata.ca, as described in Section 2.3.1 and Section 2.3.2.

Temperatures for each service location were calculated as the average temperature of each grid cell. For example, the temperature for Penetanguishene was calculated as the average temperature of cell 104, 105, 106, and 107, as referenced in Figure 1-1.

The average annual frequency for a specific time horizon represents the total number of days with temperature greater than the specified threshold divided by the number of years covered in the time horizon (e.g., 71 years for the baseline).

Days with high temperatures above 32°C are projected to increase, on average for all locations, from 7.8 days per year in 1950 to:

- 34.2 days per year in 2075 under SSP1-2.6.
- 45.2 days per year in 2075 under SSP2-4.5.
- 76.9 days per year in 2075 under SSP5-8.5.

Figure A-1 to Figure A-3 presents the number of days with temperatures above 32°C from 1950 to 2075, for each climate scenario.

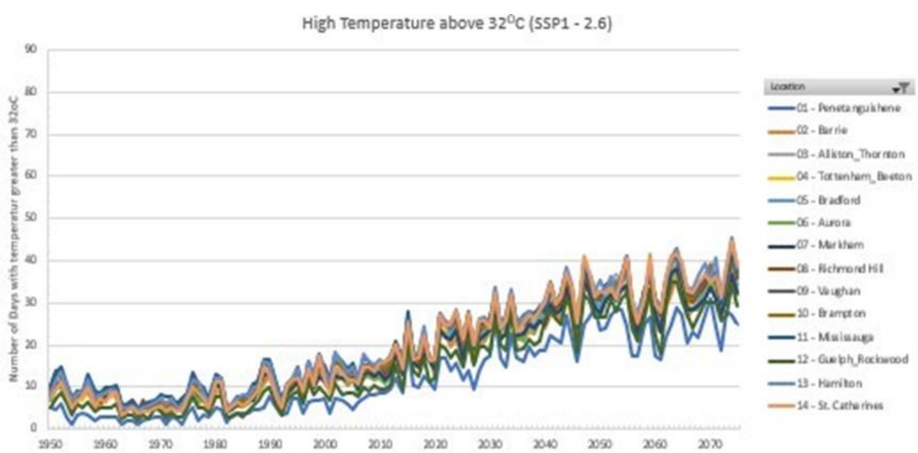


Figure A-1: Number of Days with Temperature Greater than 32°C, under SSP1-2.6

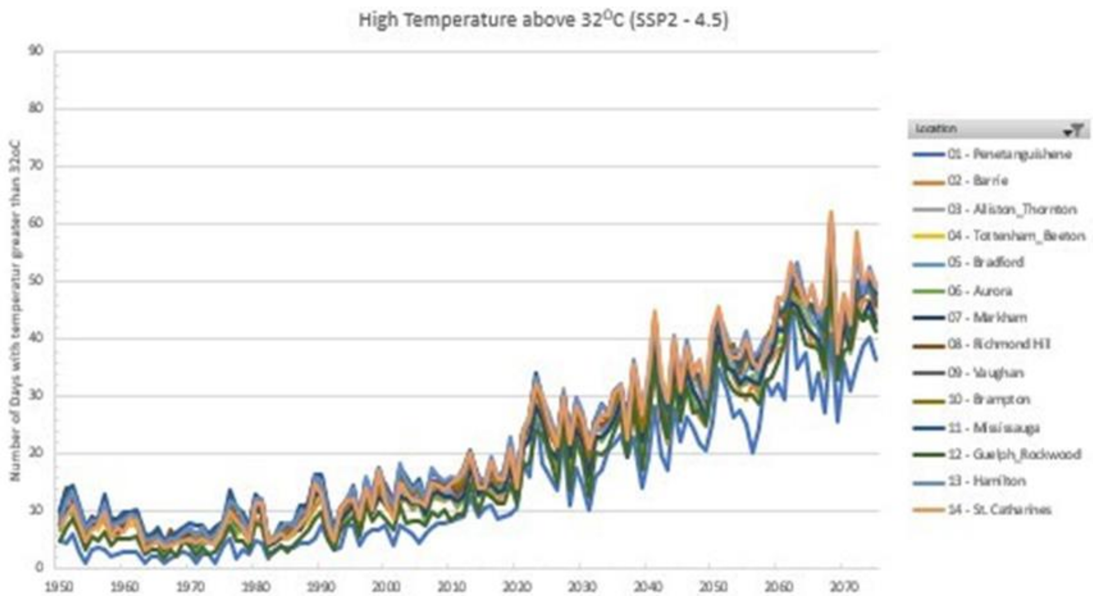


Figure A-2: Number of Days with Temperature Greater than 32°C, under SSP2-24.5

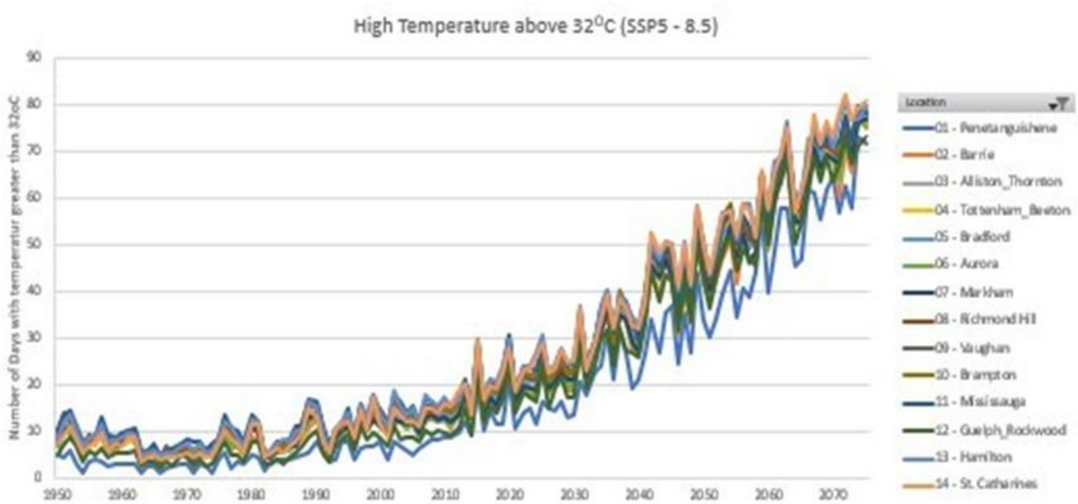


Figure A-3: Number of Days with Temperature Greater than 32°C, under SSP5-8.5

Days with high temperatures of greater than 40°C are projected to increase, on average for all locations, from zero days per year in 1950 to:

- 0.9 days per year in 2075 under SSP1-2.6.
- 2.9 days per year in 2075 under SSP2-4.5.
- 11.3 days per year in 2075 under SSP5-8.5.

Figure A-4 to Figure A-6 presents the number of days with high temperatures of greater than 40°C from 1950 to 2075, for each climate scenario.

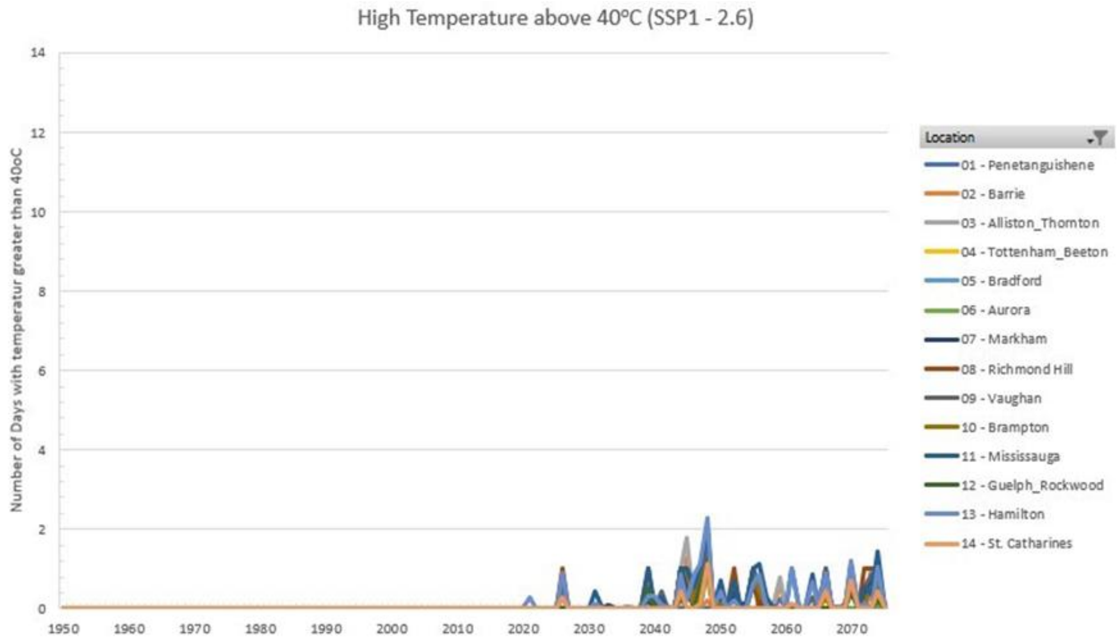


Figure A-4: Number of Days with Temperature Greater than 40°C, under SSP1-2.6

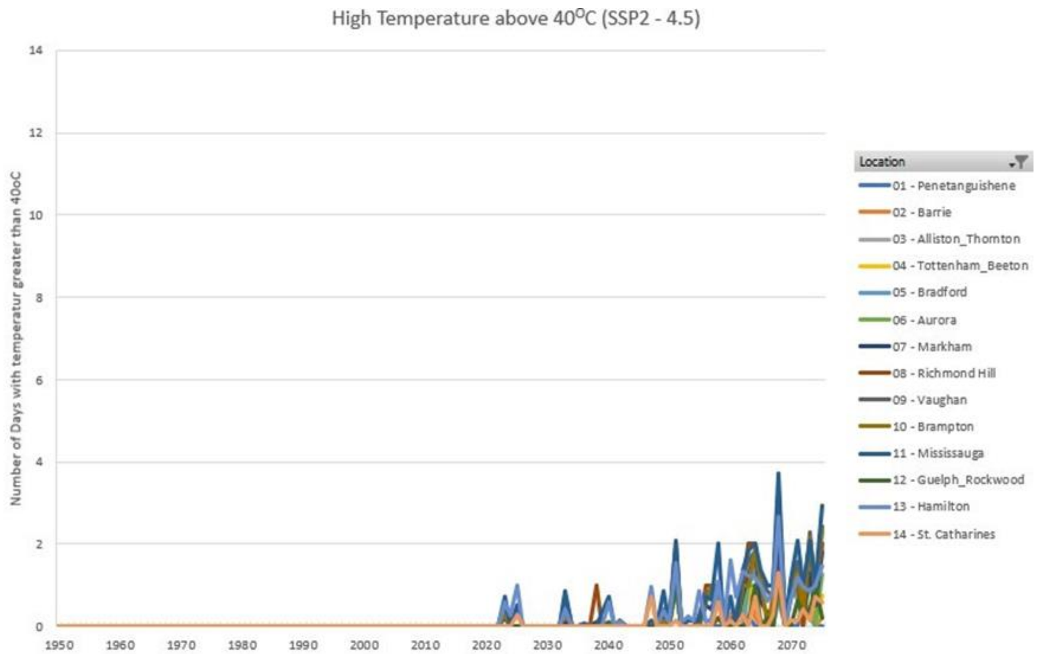


Figure A-5: Number of Days with Temperature Greater than 40°C, under SSP2-4.5

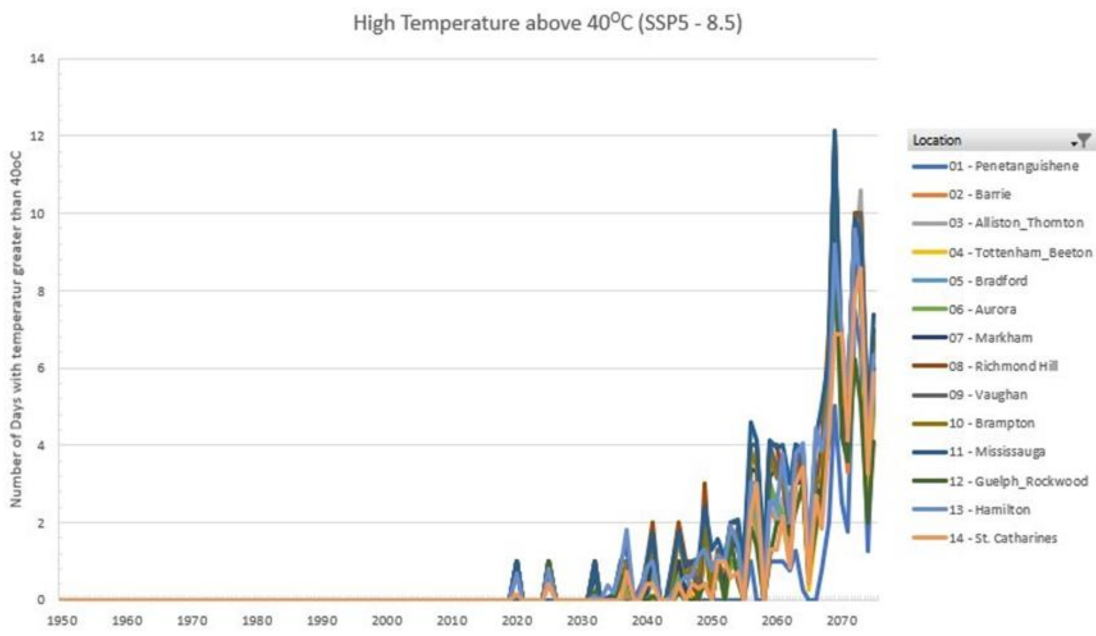


Figure A-6: Number of Days with Temperature Greater than 40°C, under SSP5-8.5

A.2 Precipitation

Precipitation was evaluated by calculating the number of days per year with the respective precipitation parameter exceeding the selected threshold. Precipitation thresholds for this Study were selected as 20mm and 50mm, as described in Section 2.1.

The annual frequencies estimated for each Alectra location were calculated for different time horizons including Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075). Historical and projected climate conditions for the different time horizons were based on data obtained from climatedata.ca, as described in Section 2.3.1 and Section 2.3.2.

Precipitation for each service location was calculated as the maximum precipitation of each grid cell. For example, the precipitation for Penetanguishene was calculated as the maximum precipitation of cell 104, 105, 106, and 107, as referenced in Figure 1-1.

The average annual frequency for a specific time horizon represents the total number of days with precipitation greater than the specified threshold divided by the number of years covered in the time horizon (e.g., 71 years for the baseline).

Days with precipitation above 20mm are projected to increase, on average for all locations, from 10.6 days per year in 1950 to:

- 11.6 days per year in 2075 under SSP1-2.6.
- 11.6 days per year in 2075 under SSP2-4.5.
- 13.4 days per year in 2075 under SSP5-8.5.

Figure A-7 to Figure A-9 presents the number of days with precipitation above 20 mm from 1950 to 2075, for each climate scenario.

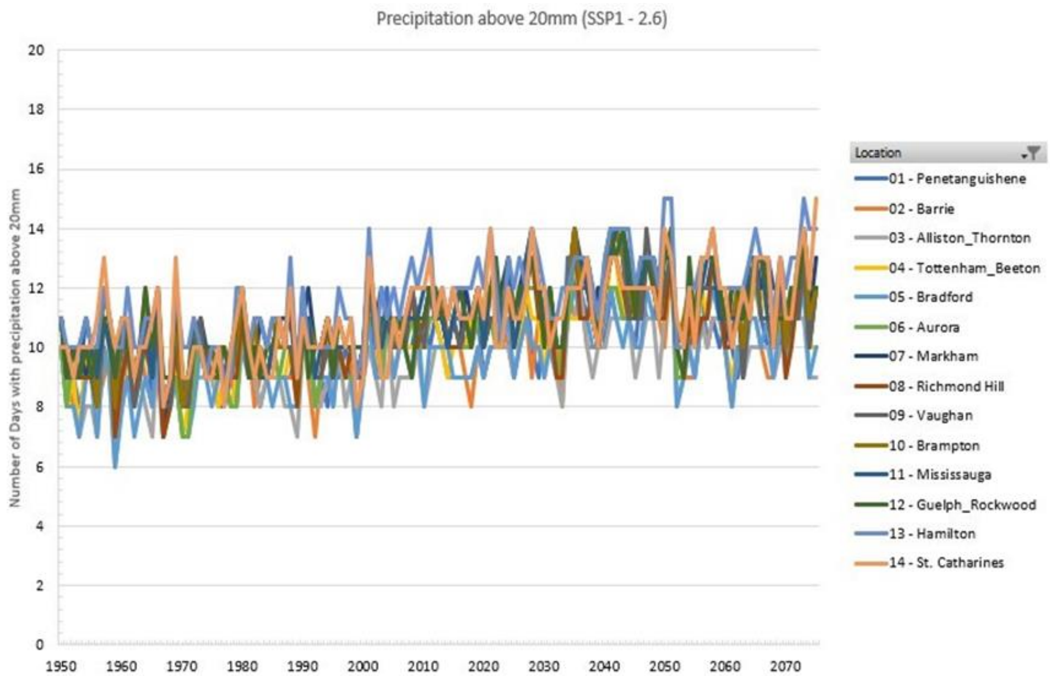


Figure A-7: Number of Days with Precipitation above 20mm, under SSP1-2.6

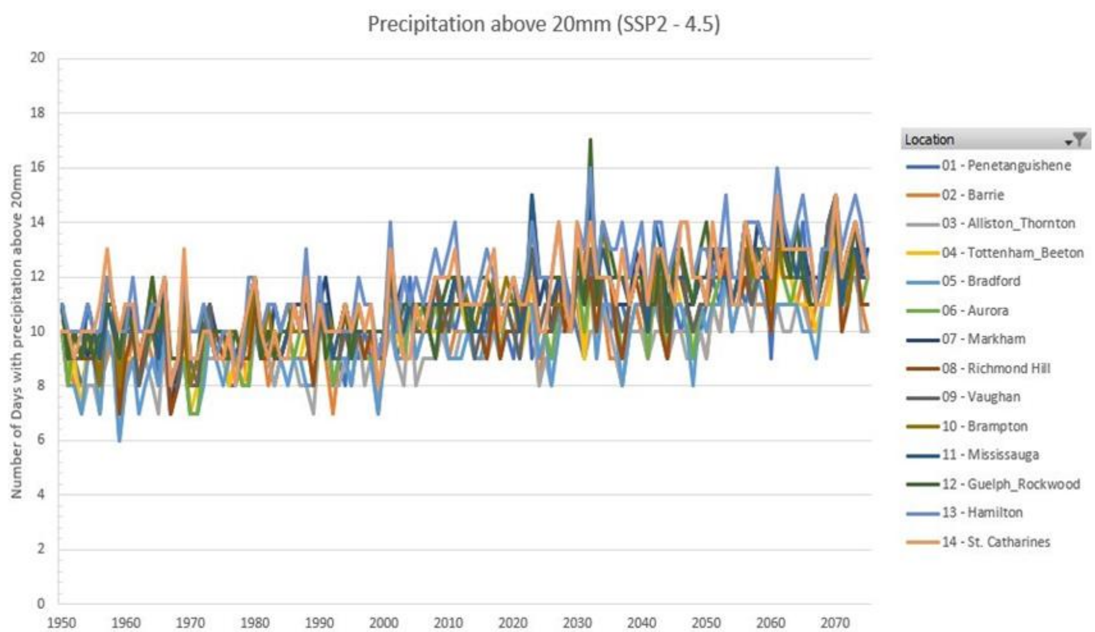


Figure A-8: Number of Days with Precipitation above 20mm, under SSP2-4.5

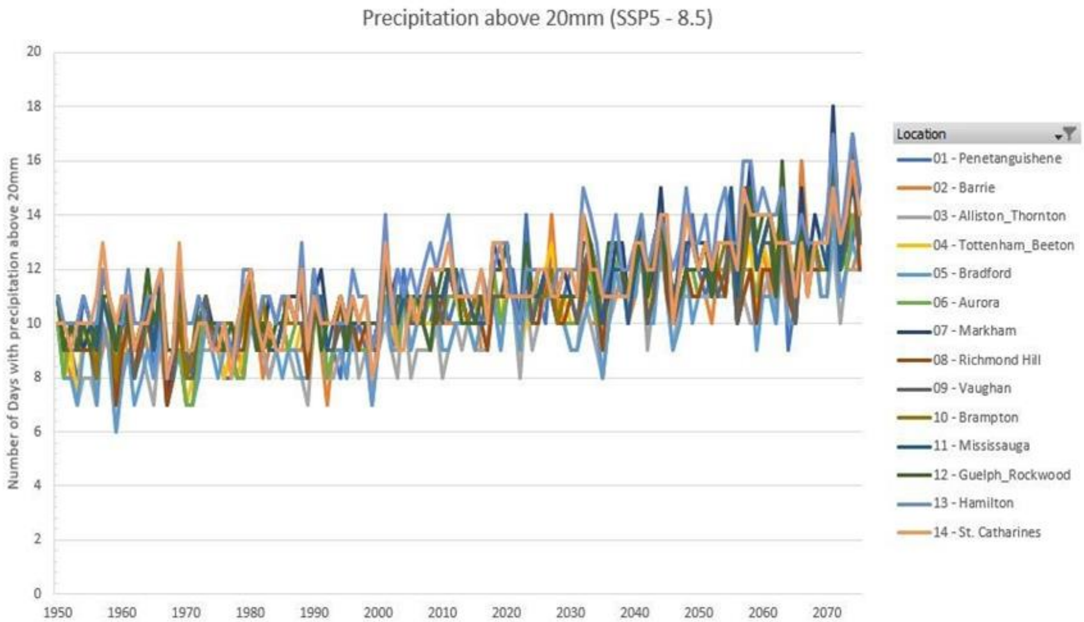


Figure A-9: Number of Days with Precipitation above 20mm, under SSP5-8.5

Days with precipitation above 50mm are projected to increase, on average for all locations, from 1.0 day per year in 1950 to:

- 1.1 days per year in 2075 under SSP1-2.6.
- 1.2 days per year in 2075 under SSP2-4.5.
- 1.0 days per year in 2075 under SSP5-8.5

Figure A-10 to Figure A-12 presents the number of days with precipitation above 50 mm from 1950 to 2075, for each climate scenario.

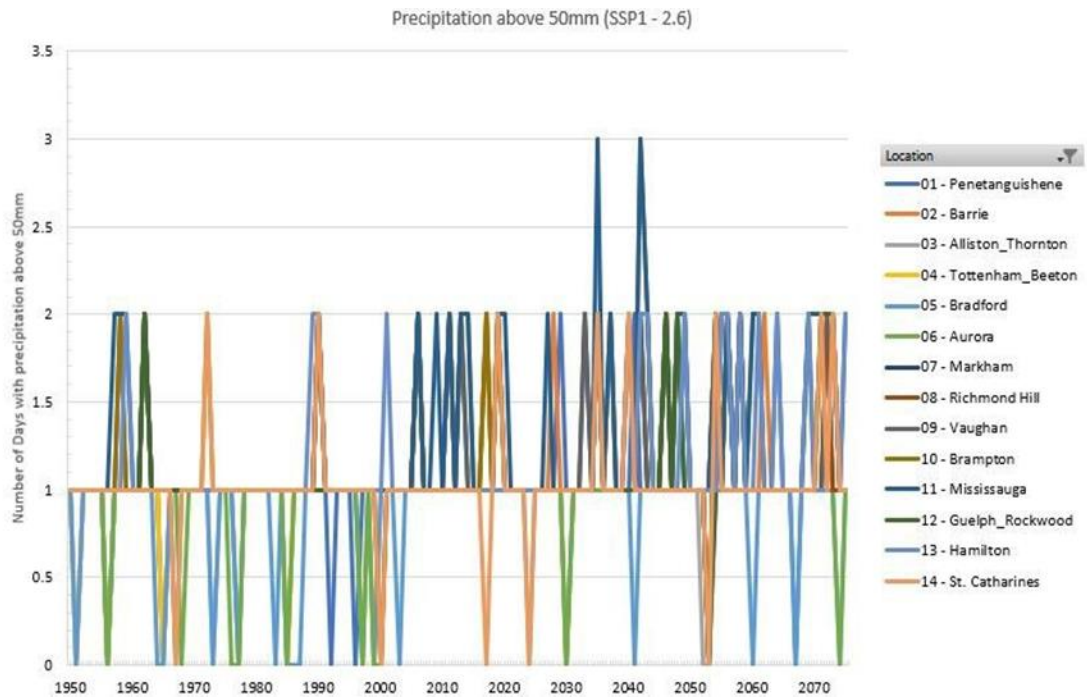


Figure A-10: Number of Days with Precipitation above 50mm, under SSP1-2.6

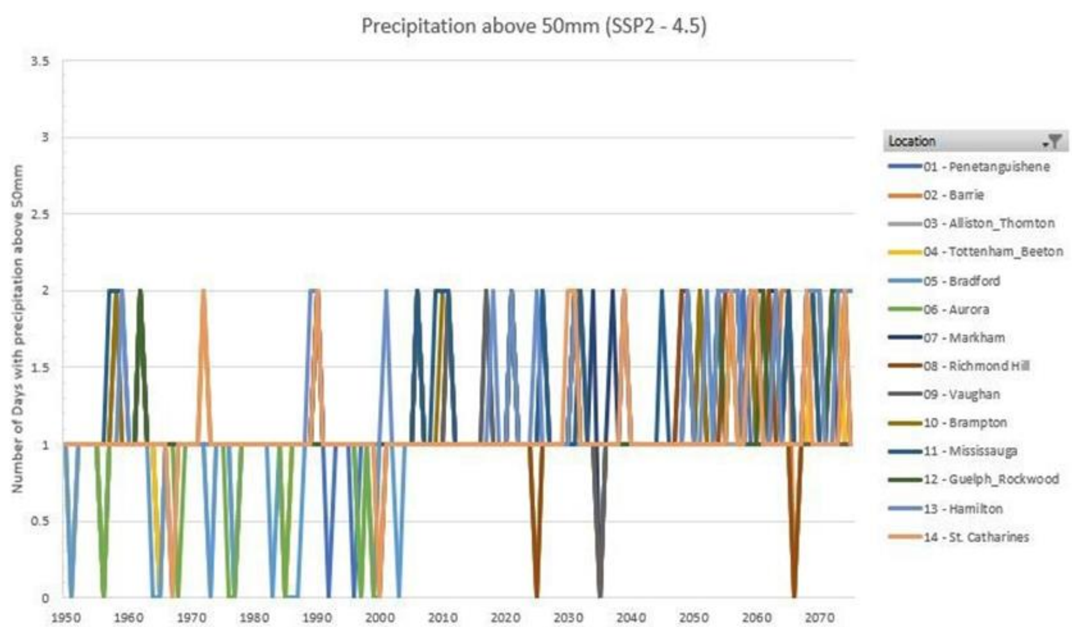


Figure A-11: Number of Days with Precipitation above 50mm, under SSP2-4.5

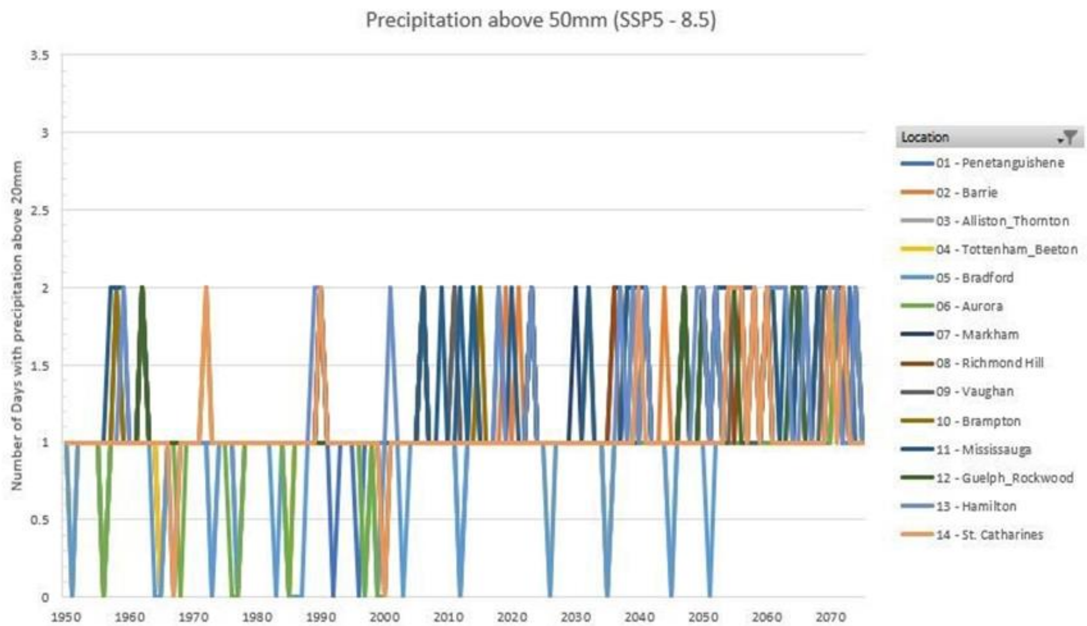


Figure A-12: Number of Days with Precipitation above 50mm, under SSP5-8.5

A.3 Wind Gusts

Winds gusts were evaluated by calculating the number of hours per year with the respective wind gust parameters exceeding the selected threshold. Winds gusts thresholds for this Study were selected as follows:

- Winds gusts below 60km/h.
- Winds gusts between 61 and 80 km/h.
- Winds gusts between 81 and 100 km/h.
- Winds gusts between 101 and 120 km/h.
- Winds gusts over 121 km/h.

The annual frequencies estimated for each Alectra location were calculated for different time horizons including Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075).

Historical climate profiles were obtained from Environment and Climate Change Canada weather stations, as described in Section 2.3.1. The stations used to cover Alectra's entire service territory, along with their coordinates, are presented in Table A-1. When wind gusts were unavailable in the hourly historical data, a gust factor of 1.75 was applied, as recommended by

World Meteorological Association[25]. A Weibull distribution was fitted on the observations to estimate the probability of wind gusts at higher wind speeds. The Weibull distribution is typically used to model the distribution of wind speeds values.

Projected climate conditions were for the different study periods were based on data obtained from the IPCC atlas, as described in Section 2.3.2.

Table A-1: Reference ECCC Weather Stations Data

Station Name	Station ID	Latitude	Longitude
HAMILTON A	6153193	43°10'25.000" N	79°56'06.000" W
VINELAND STATION RCS	6139148	43°11'00.000" N	79°24'00.000" W
ST CATHARINES A	6137287	43°12'00.000" N	79°10'00.000" W
HAMILTON RBG CS	6153301	43°17'30.000" N	79°54'30.000" W
KITCHENER/WATERLOO	6144239	43°27'39.000" N	80°22'43.000" W
GUELPH TURFGRASS INSTITUTE	6143092	43°32'30.741" N	80°13'19.492" W
TORONTO INTL A	6158731	43°40'36.000" N	79°37'50.000" W
TORONTO BUTTONVILLE A	6158410	43°51'39.000" N	79°22'07.000" W
EGBERT CS	611E001	44°14'00.000" N	79°47'00.000" W
BORDEN AWOS	611B002	44°16'20.000" N	79°54'42.000" W
BARRIE LANDFILL	6110556	44°23'07.000" N	79°44'10.000" W
BARRIE-ORO	6117700	44°29'00.000" N	79°33'00.000" W
COLLINGWOOD	6111792	44°30'00.000" N	80°13'00.000" W

Wind gusts for each service location were calculated as the maximum wind gust of each grid cell. For example, the wind gust for Penetanguishene was calculated as the average of cells 104, 105, 106, and 107, as referenced in Figure 1-1.

The average annual frequency for a specific time horizon represents the total number of hours with wind gusts greater than the specified threshold divided by the number of years covered in the time horizon (e.g., 71 years for the baseline).

Hours with wind gusts below 60km/h are projected to slightly decrease, on average for all locations, from 8,593 hours per year in the baseline period to:

- 8,591 hours per year in the long term (2081-2100) under SSP1-2.6.
- 8,590 hours per year in the long term (2081-2100) under SSP2-4.5.
- 8,587 hours per year in the long term (2081-2100) under SSP5-8.5

[25] World Meteorological Organization (WMO). 2010. Guidelines for Converting between Various Wind Averaging Periods in Tropical Cyclone Conditions. WTO/TD-No. 1555

Figure A-13 to Figure A-15, presents the number of hours with wind gusts below 60km/h, for each time horizon and for each climate scenario.

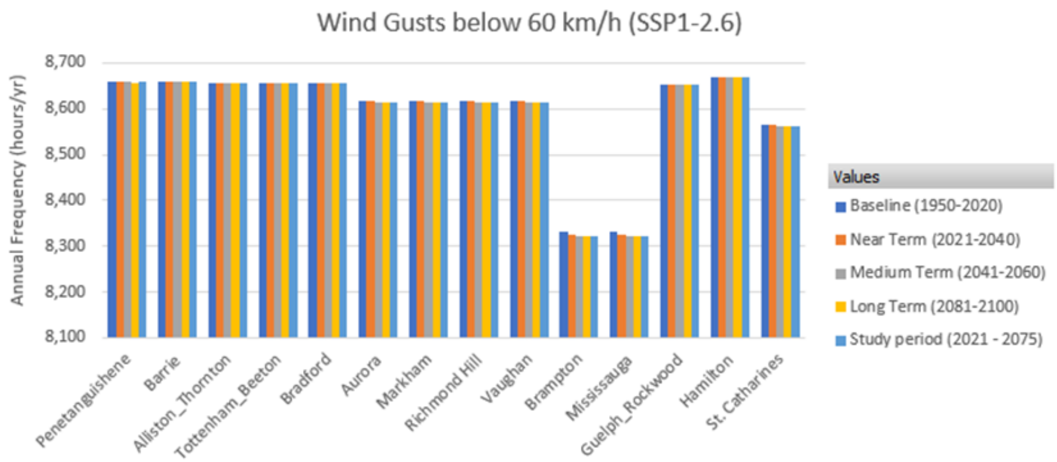


Figure A-13. Annual Frequency for Wind Gusts below 60km/h, under SSP1-2.6

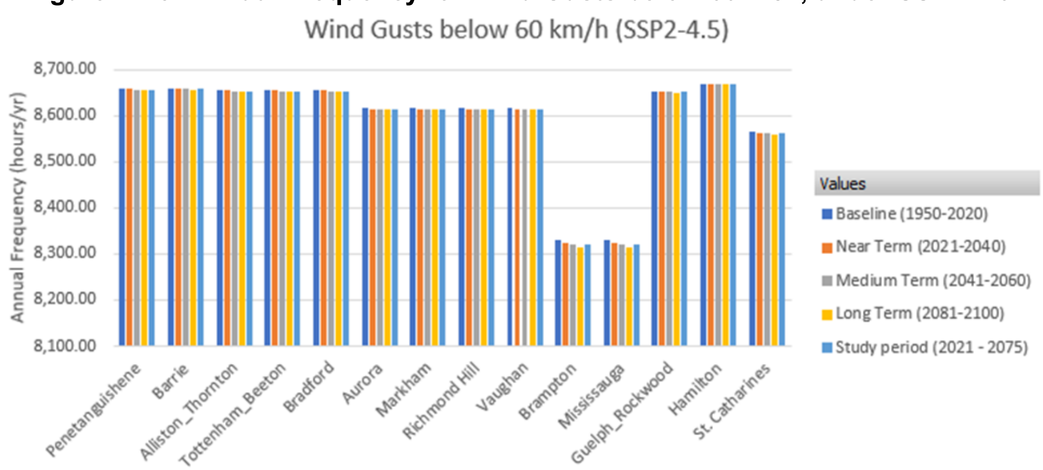


Figure A-14: Annual Frequency for Wind Gusts below 60km/h, under SSP2-4.5

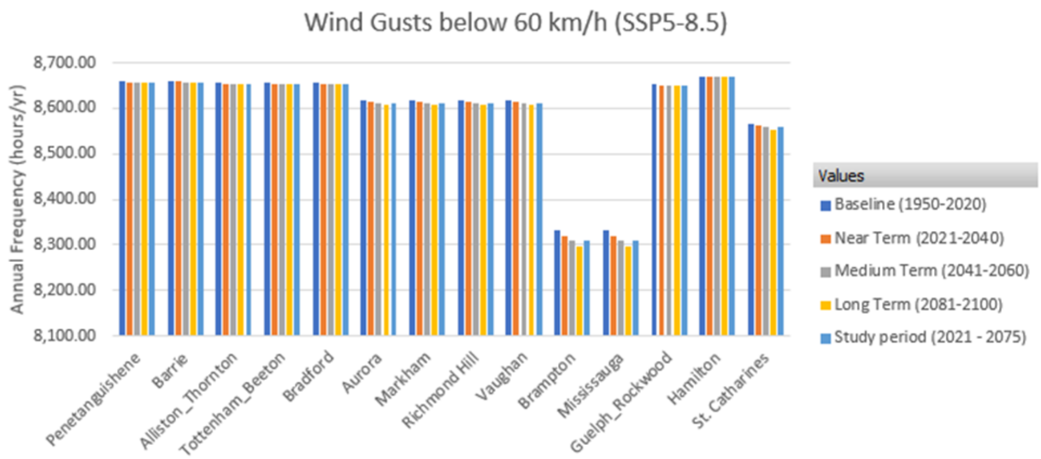


Figure A-15: Annual Frequency for Wind Gusts below 60km/h, under SSP5-8.5

Hours with wind gusts between 61 and 80 km/h are projected to increase, on average for all locations, from 156 hours in the baseline period to:

- 160 hours in the long term (2081-2100) under SSP1-2.6.
- 161 hours in the long term (2081-2100) under SSP2-4.5.
- 166 hours in the long term (2081-2100) under SSP5-8.5.

Figure A-16 to Figure A-18 present the number of hours with wind gusts between 61 and 80 km/h, for each time horizon and for each climate scenario.

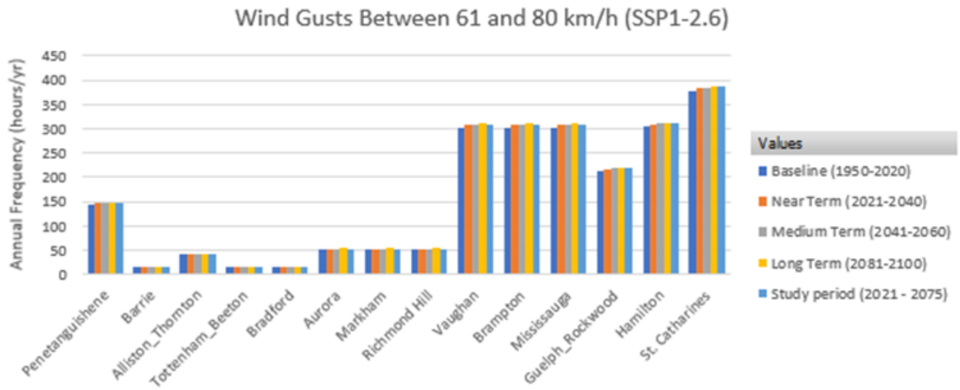


Figure A-16: Annual Frequency for Wind Gusts between 61 km/h to 80 km/h, under SSP1-2.6

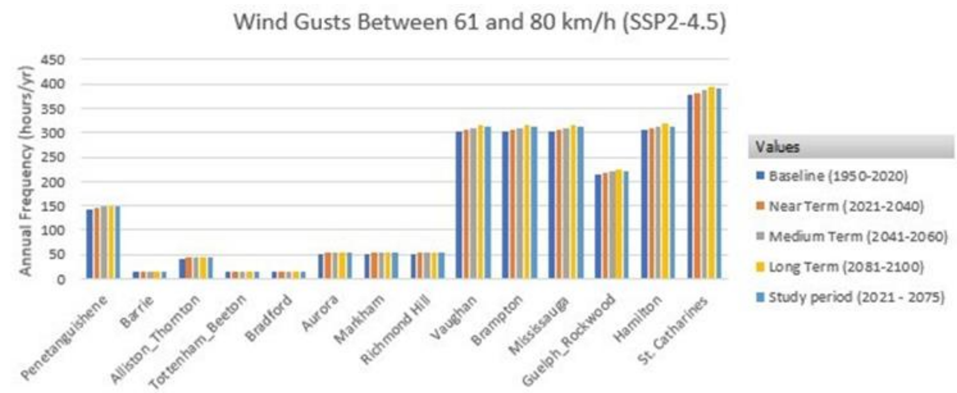


Figure A-17: Annual Frequency for Wind Gusts between 61 km/h to 80 km/h, under SSP2-4.5

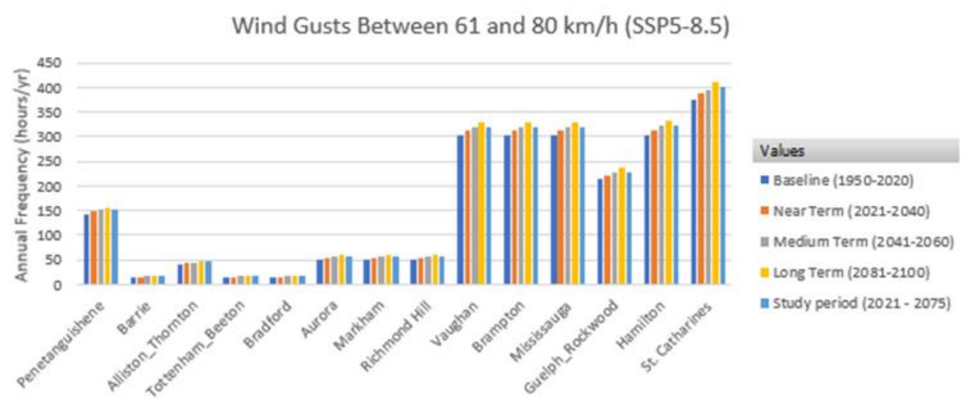


Figure A-18: Annual Frequency for Wind Gusts between 61 km/h to 80 km/h, under SSP5-8.5

Hours with wind gusts between 81 and 100 km/h are projected to increase, on average, from 16 hours in the baseline period to:

- 17 hours in the long term (2061-2075) under SSP1-2.6.
- 17 hours in the long term (2061-2075) under SSP2-4.5.
- 19 hours in the long term (2061-2075) under SSP5-8.5.

Figure A-19 to Figure A-21, presents the number of hours with wind gusts between 81 and 100 km/h, for each time horizon and for each climate scenario.

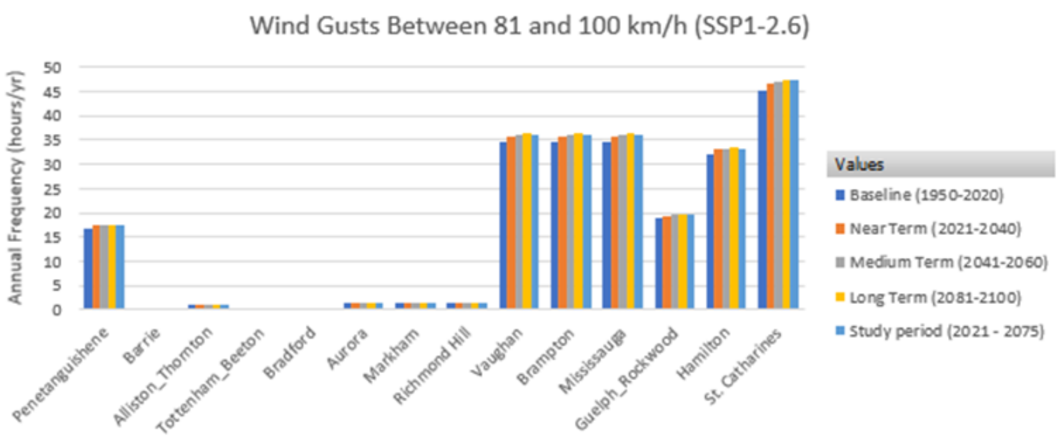


Figure A-19: Annual Frequency for Wind Gusts between 81 km/h to 100 km/h, under SSP1-2.6

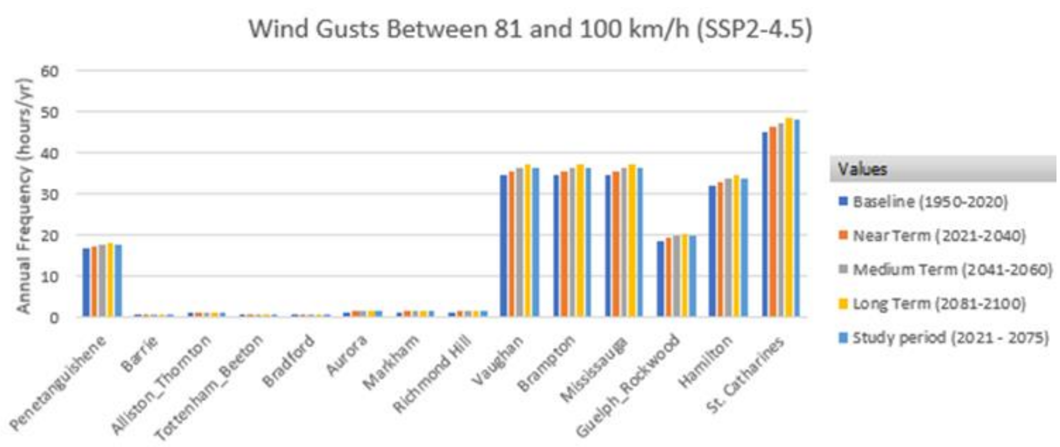


Figure A-20: Annual Frequency for Wind Gusts between 81 km/h to 100 km/h, under SSP2-4.5

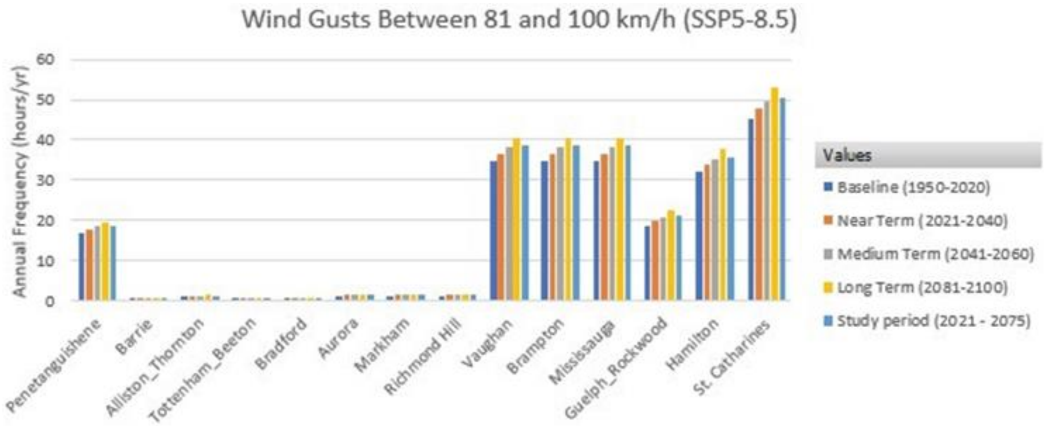


Figure A-21: Annual Frequency for Wind Gusts between 81 km/h to 100 km/h, under SSP5-8.5

Hours with wind gusts between 101 and 120 km/h are projected to increase, on average for all locations, from 1.0 hours in the baseline period (1950-2020) to:

- 1.1 hours in the long term (2061-2075) under SSP1-2.6.
- 1.2 hours in the long term (2061-2075) under SSP2-4.5.
- 1.3 hours in the long term (2061-2075) under SSP5-8.5.

Figure A-22 to Figure A-24, presents the number of hours with wind gusts between 101 and 120 km/h, for each time horizon and for each climate scenario.

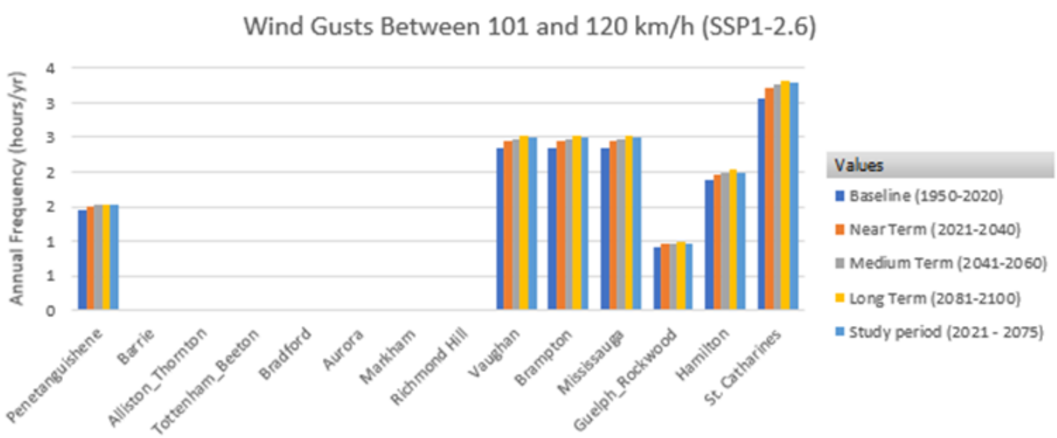


Figure A-22: Annual Frequency for Wind Gusts between 101 km/h to 120 km/h, under SSP1-2.6

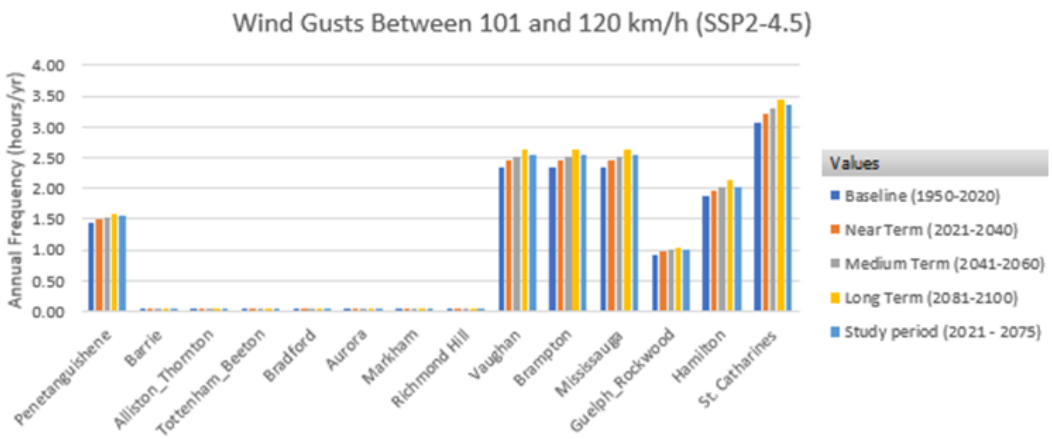


Figure A-23: Annual Frequency for Wind Gusts between 101 km/h to 120 km/h, under SSP2-4.5

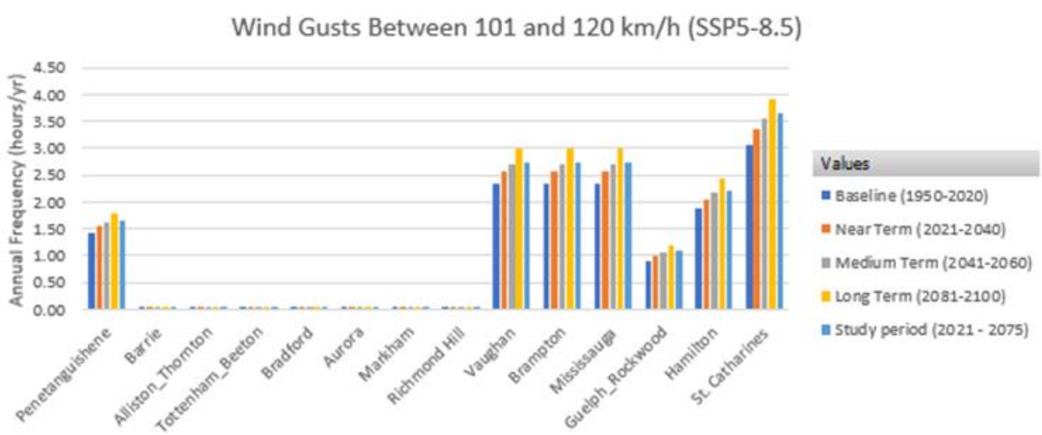


Figure A-24: Annual Frequency for Wind Gusts between 101 km/h to 120 km/h, under SSP5-8.5

Hours with wind gusts over 121 km/h are projected to increase, on average for all locations, from 0.04 hours in the baseline period (1950-2020) to:

- 0.05 hours in the long term (2061-2075) under SSP1-2.6.
- 0.05 hours in the long term (2061-2075) under SSP2-4.5.
- 0.06 hours in the long term (2061-2075) under SSP5-8.5.

Figure A-25 to Figure A-27 present the number of hours with wind gusts over 121 km/h, for each time horizon and for each climate scenario.

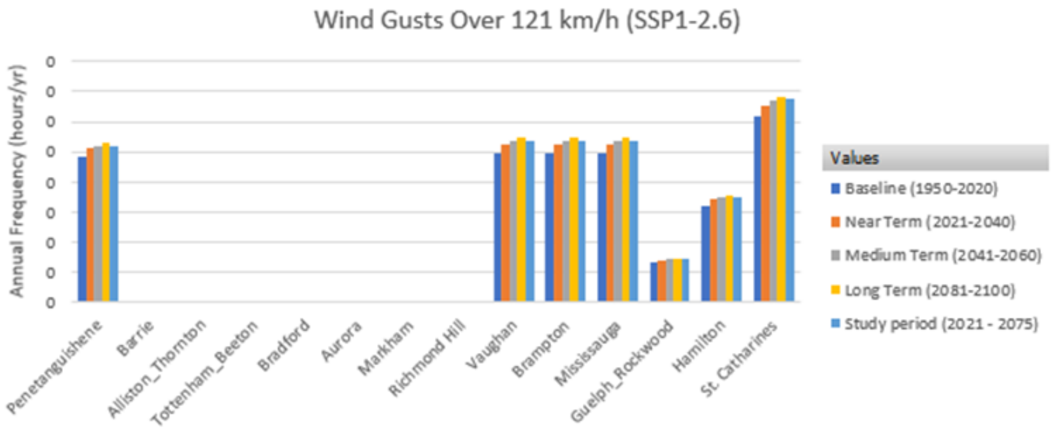


Figure A-25: Annual Frequency for Wind Gusts Over 121 km/h, under SSP1-2.6

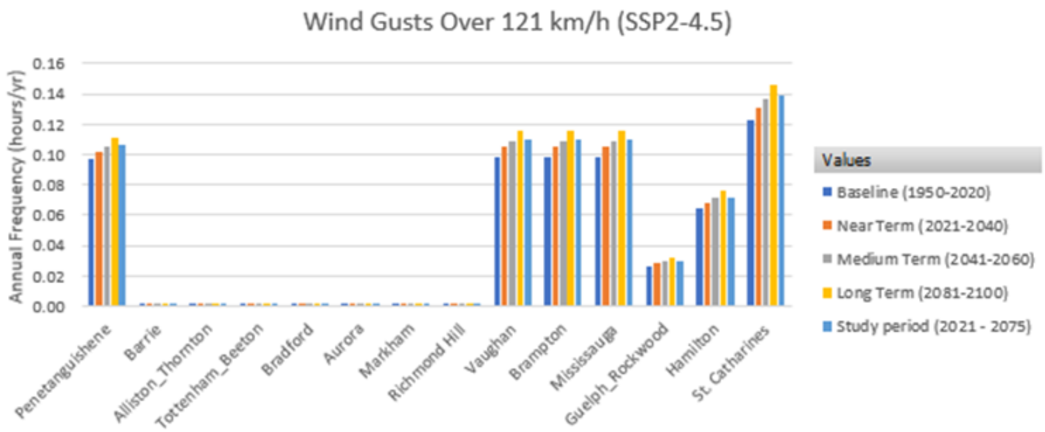


Figure A-26: Annual Frequency for Wind Gusts Over 121 km/h, under SSP2-4.5

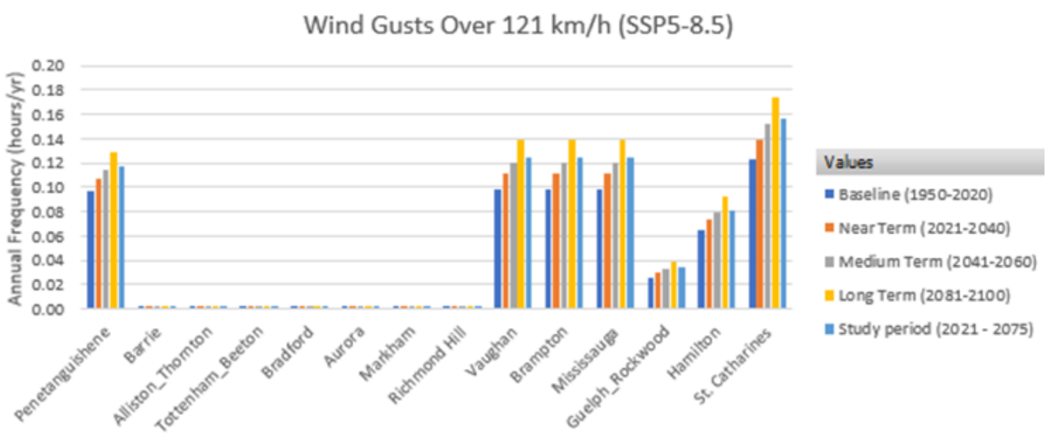


Figure A-27: Annual Frequency for Wind Gusts Over 121 km/h, under SSP5-8.5

A.4 Tornadoes

Tornadoes were evaluated using the number of occurrences per year. A historical baseline was established using the Canadian Tornado Database (1981-2009)[26]. Projections were generated through literature review of publicly available studies.

Environment and Climate Change Canada (ECCC) adopted the updated "Enhanced Fujita" or EF-Scale in April 2013 to measure the intensity of wind damage. The historical dataset under the old "F-Scale" was maintained, and the EF-Scale has been used thereafter.

Table A-2 summarizes the F-Scale wind speed rounded to 10 km/h, and the EF-Scale wind speed, rounded to 5 km/h.

Table A-2: F-Scale and EF- Scale

EF-Scale Rating	F-Scale Wind Speed Rounded to 10 km/h	EF-Scale Wind Speed Rounded to 5 km/h
0	60-110	90-130
1	120-170	135-175
2	180-240	180-220
3	250-320	225-265
4	330-410	270-310
5	420-510	315 or more

The 29 -year national tornado database provides a record of all existing tornadoes by Fujita scale from 1980 to 2009[26]. Based on the record of occurrence, a total of 378 tornadoes occurred in Ontario between 1980 and 2009, and 44 tornadoes were recorded in the same period within Alectra's service zones.

Figure A-28 illustrates the location of the verified tornadoes in Canada[26], while Figure A-29 illustrates the number of tornadoes (F0 to F5) between 1980 and 2009 in Ontario. Figure A-30 illustrates the location of the verified tornadoes within Alectra's service zones.

[26] Environment and Climate Change Canada. Canadian National Tornado Database: Verified Tracks (1980-2009). Available from: Canadian National Tornado Database: Verified Tracks (1980-2009) - Public GIS EN - Open Government Portal (canada.ca)

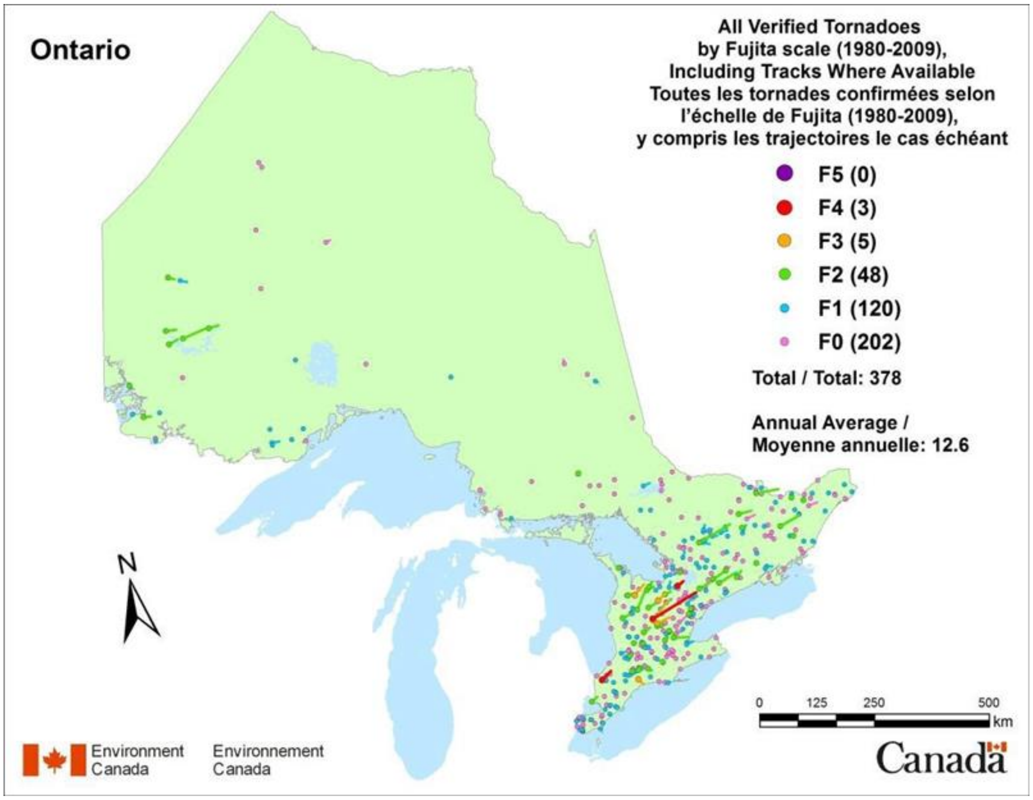


Figure A-28: Verified Tornadoes Records of 1980-2009 by Environment Canada

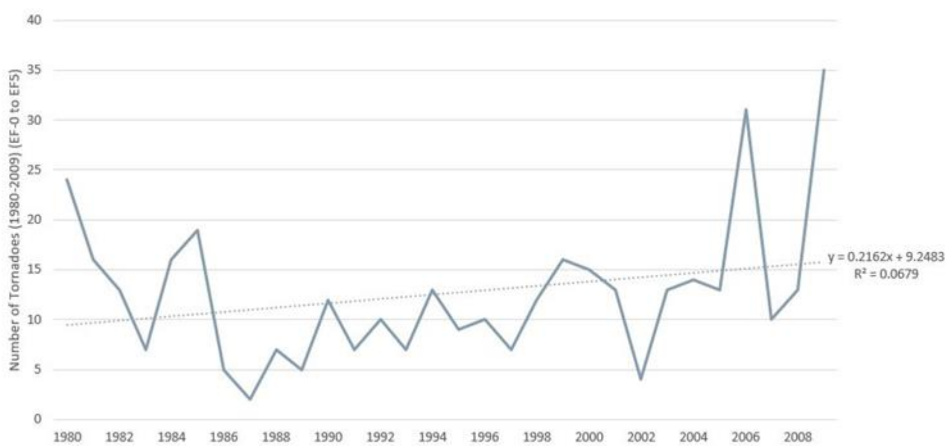


Figure A-29: Number of Tornadoes in Ontario (EF-0 to EF-5) between 1980 and 2009

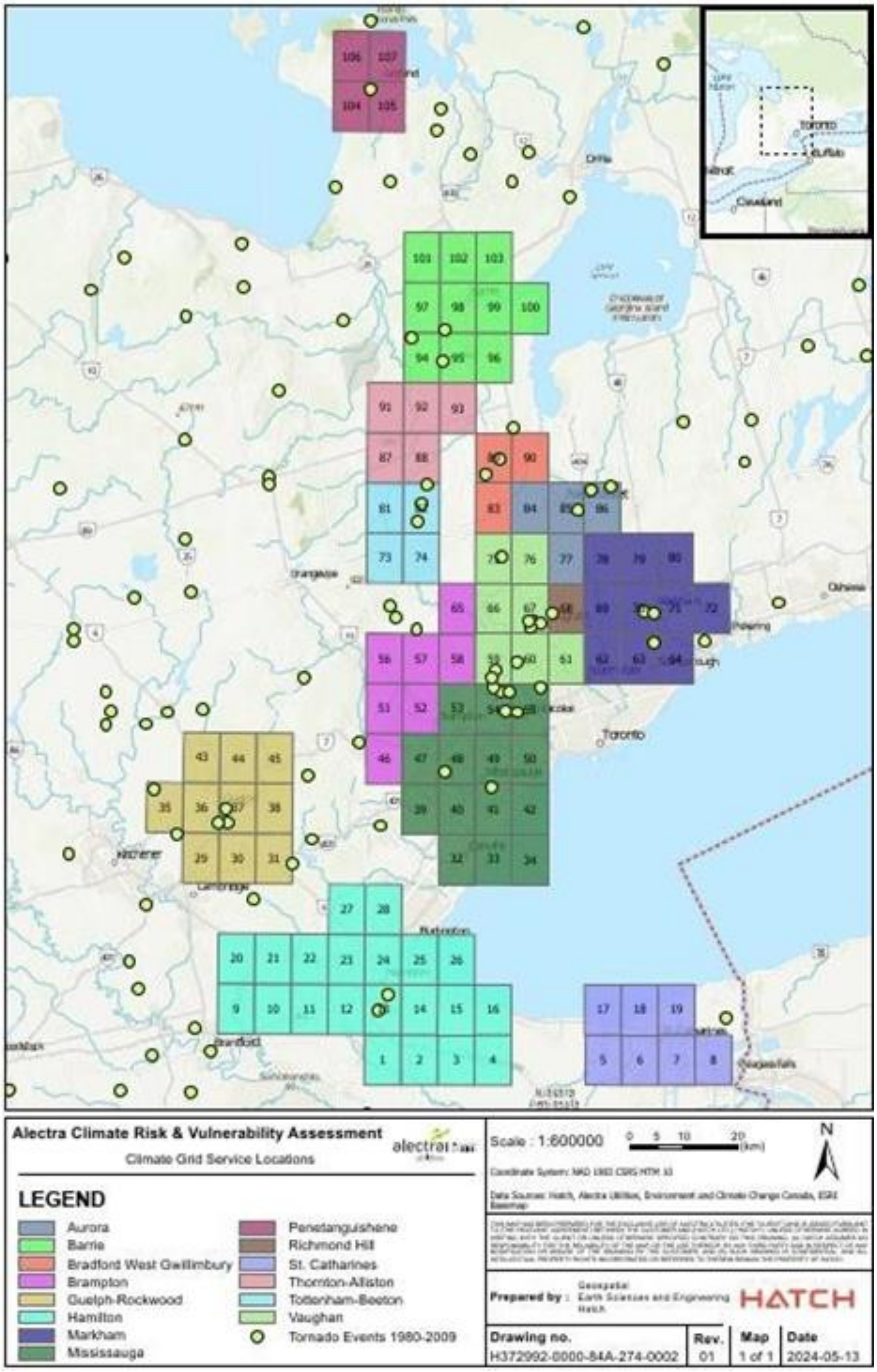


Figure A-30: Verified Tornadoes Records of 1980-2009 by Environment Canada in Alectra Service Zones

The impacts of climate change on tornado frequency and intensity are still uncertain; however recent events in the US are suggesting a stronger correlation with a potential increase in the number of events than previously considered. Conditions that may be precursors to tornadoes, such as severe thunderstorms, are projected to increase[27], which may be an indication that tornado frequency or intensities may increase. This information is in line with the findings presented in Figure A-29 showing the number of tornadoes in Ontario (EF-0 to EF-5) from 1980 to 2009.

Based on the information presented above, the frequency of tornadoes in the Alectra service zone was determined as 0.00023 events/yr/km^2, based on the following parameters:

- 44 tornado events in 30 years, resulting in 1.5 events per year.
- Geographical extension of Alectra's service zone (estimated based on the number of cells as referenced in Figure 1-1) is 6,420 km^2 (107 cells x 60 km^2/ cell).

The annual frequencies for each Alectra location were estimated based on the geographical extension of a service location, considering the numbers of grid cell (as referenced in Figure 1-1) and the size of each grid. For example, the annual frequency of a tornado in Penetanguishene was estimated as 0.00023 events/yr/km^2 times 240 km^2 (4 cells x 60 km^2/ cell).

The projected annual frequencies for each Alectra service zone were calculated for different time horizons including Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075). The annual frequencies for the different study periods were estimated based on the increased in tornadoes from 1980 to 2009, as presented in Figure A-29.

[27] Cheng, Vincent Y. S., George B. Arhonditsis, David M. L. Sills, Heather Auld, Mark W. Shephard, William A. Gough, and Joan Klaassen. "Probability of Tornado Occurrence across Canada." Journal of Climate 26, no. 23 (December 2013): 9415–28. https://doi.org/10.1175/JCLI-D-13-00093.1.

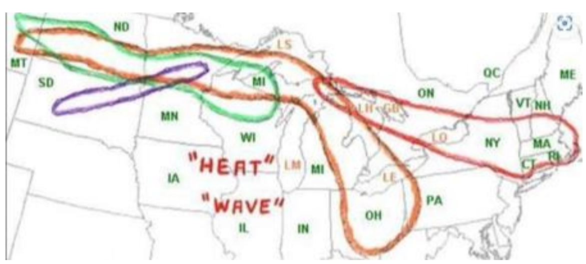
A.5 Derechos

A derecho is a widespread, long-lived windstorm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to the strength of tornadoes, the damage typically is directed in one direction along a relatively straight swath. If the wind damage swath extends more than 240 miles (about 400 kilometers) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, then the event may be classified as a derecho[28].

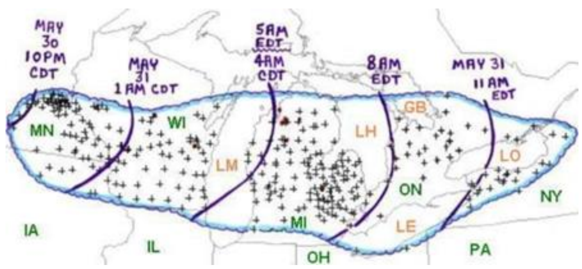
Derechos were evaluated using the number of occurrences per year. While the historical baseline was established based on historical derecho events, projections were generated through literature review and specialized studies.

The first derecho recorded in North America was in 1987. Starting in the 1960s, derecho events were recorded more frequently. For the purpose of this Study, a baseline of 60 years was used to account for derecho events in the Alectra Service Zones and in the close proximity to them. Based on a literature review, three (3) derechos have occurred within this area in the last 60 years, as presented in Table A-3. Therefore, the frequency of occurrence for the baseline period (1950-2020) was determined as 0.05 events/yr.

Table A-3: Derecho Events in Alectra Service Zone[28,29]

Event	Date	Description
Heat wave of 1995 derecho series	July 11–15, 1995	4 derechos occurred over 4 consecutive nights. The first derecho formed in eastern Montana and dissipated over Minnesota. A second derecho followed a nearly identical path before turning south over Michigan and dissipating over Ohio. A derecho formed over central South Dakota and moved northeast before dissipating over northeast Minnesota. The final derecho formed over northern Michigan and moved southeast over the Northeast dissipating over the Atlantic Ocean producing 100mph winds over Ontario and New York. A map of the four derechos of the July 1995 Derecho Event is presented in the image below. 

28 ABOUT DERECHOS. Part of the NOAA-NWS-NCEP Storm Prediction Center web site Prepared by Stephen F. Corfidi, Jeffry S. Evans, and Robert H. John. Available from: [Facts About Derechos - Very Damaging Windstorms (noaa.gov)]
29 The weather Network. 2022. Nearly Half of Canada's Population Hit by Derecho, Why It Was So Harmful. Available from: [Nearly half of Canada's population hit by derecho, why it was harmful - The Weather Network]

Event	Date	Description
Late-May 1998 tornado outbreak and derecho	May 30–31, 1998	Formed out of a tornado outbreak over South Dakota that produced the F-4 Spencer tornado. The derecho swept across southern Minnesota and northern Iowa producing 80-100mph winds. It crossed into Wisconsin bringing widespread damage to almost the entire state with 100- 128mph winds being reported from northern Madison to northern Milwaukee. It crossed into Michigan bringing 60- 90mph winds to the entire state with the southern counties being hit with 120-130mph winds. The event caused the largest power outage recorded in the state's history. It crossed the state at a blistering 70mph and entered Ontario bringing 75mph winds. The line would dissipate over New York. 6 people were killed in the derecho and more than 2 million people lost power. A severe weather report map of the May 30-31, 1998, derecho and tornado outbreak is presented in the image below. 
May 2022 Canadian Derecho	May 21, 2022	A fast-moving, intense derecho formed in St. Clair County, Michigan near Sarnia, Ontario, progressing through the London, Toronto, Ottawa, Montreal, and Quebec City metropolitan areas, killing at least ten people, and causing extensive damage and power outages affecting an estimated 480,000 people. Wind gusts of over 75 mph (120 km/h) were reported in Windsor, as well as at the Ottawa and Toronto international airports. Kitchener/Waterloo Airport recorded a peak wind gust of 82 mph (132 km/h). Within the Derecho, four Tornadoes, three EF2's and one EF1 touched down in Southern Ontario. Post storm damage investigation analysis identifies maximum wind speeds reaching 120 mph (190 km/h) in a 3.1mi (5 km) corridor in Ottawa, resulting from embedded downbursts. A map of the May 2022 Canadian Derecho is presented in the image below. 

According to the National Oceanic and Atmospheric Administration (NOAA)[28], derechos occur in Southern Ontario approximately once every four years, as illustrated in Figure A-31: Derecho Frequency. This translates to an estimated annual frequency of 0.25 events per year for the entire study period, from 2021 to 2075. The baseline frequency is derived from historical records within the Alectra service area, while the study period estimates are based on NOAA's broader regional recommendations.

Figure A-31: Derecho Frequency

A.6 Ice Storms

Ice storms were evaluated using the number of ice storms per year. While the baseline was established based on historical events, projections were generated through literature review and specialized studies.

Historically, Ontario has seen 10 ice storms in the past 29 years (1995 – 2023), as presented in Table A-4. Therefore, the frequency for the baseline period (1950-2020) has been defined as once every 2.9 years (or 0.34 events per year).

Table A-4: Historical Ice Storms

Data	Description
December 1995	Southern Ontario, 1015 cm snow, wind 90 km/h, -40 degrees, traffic closures
January 1998	Ontario-New Brunswick
January 1998	Freezing rain (50 - 100 mm) Kingston-Ottawa-Montreal, total >3 m people without power
January 1999	Southern Ontario
January 1999	Toronto, total 118 cm snow, emergency, winds 70 km/h, ice, freezing rain, Pearson closed
December 2006	Russel (south of Ottawa) freezing rainstorm
December 2013	Southern Ontario, Toronto 30 mm ice, downed wires, and trees
April 2018	Toronto, Hamilton 100 km/h,
January 2020	78 mm rain in Toronto, frozen ground, tree damage, power outages
April 2023	Ontario/ Quebec winter storm

Based on a literature review, it was determined that the climate change impact on ice storm frequencies and intensity in Ontario is still speculative and therefore uncertain. Current publicly available climate modelling does not provide a quantitative indication of change in ice storm frequency. Therefore, this Study assumes that the frequency of ice storms observed in the future years will stay unchanged as 0.34 events per year.

Appendix B
Likelihood Maps

The likelihood maps in this Appendix present the results of the likelihood scores calculated as detailed in Section 3.5. Detail scores for each Alectra Service Zone level is provided in Appendix C.

B.1 Temperature

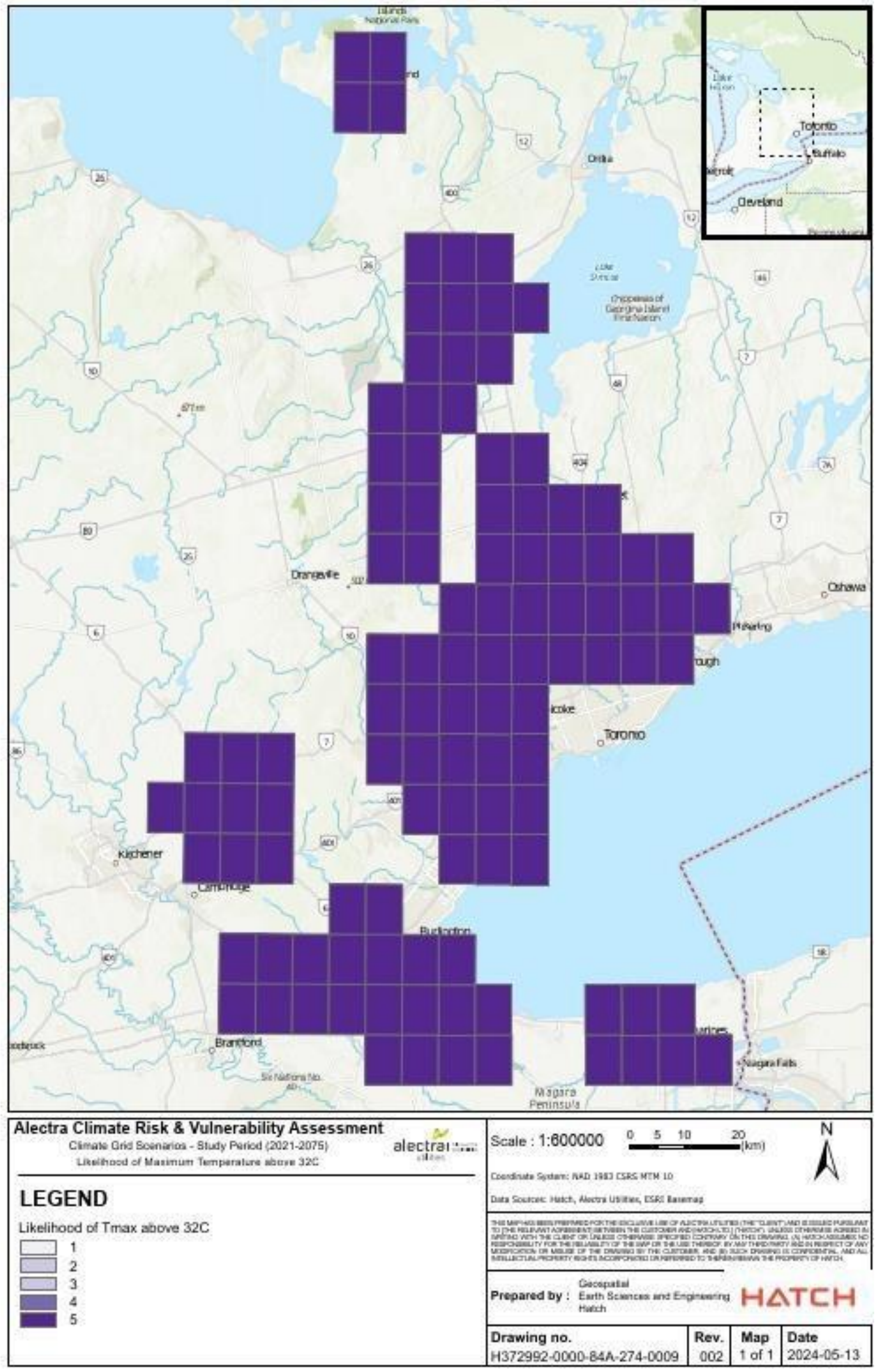


Figure B-1: Likelihood Map for Temperature Above 32°C

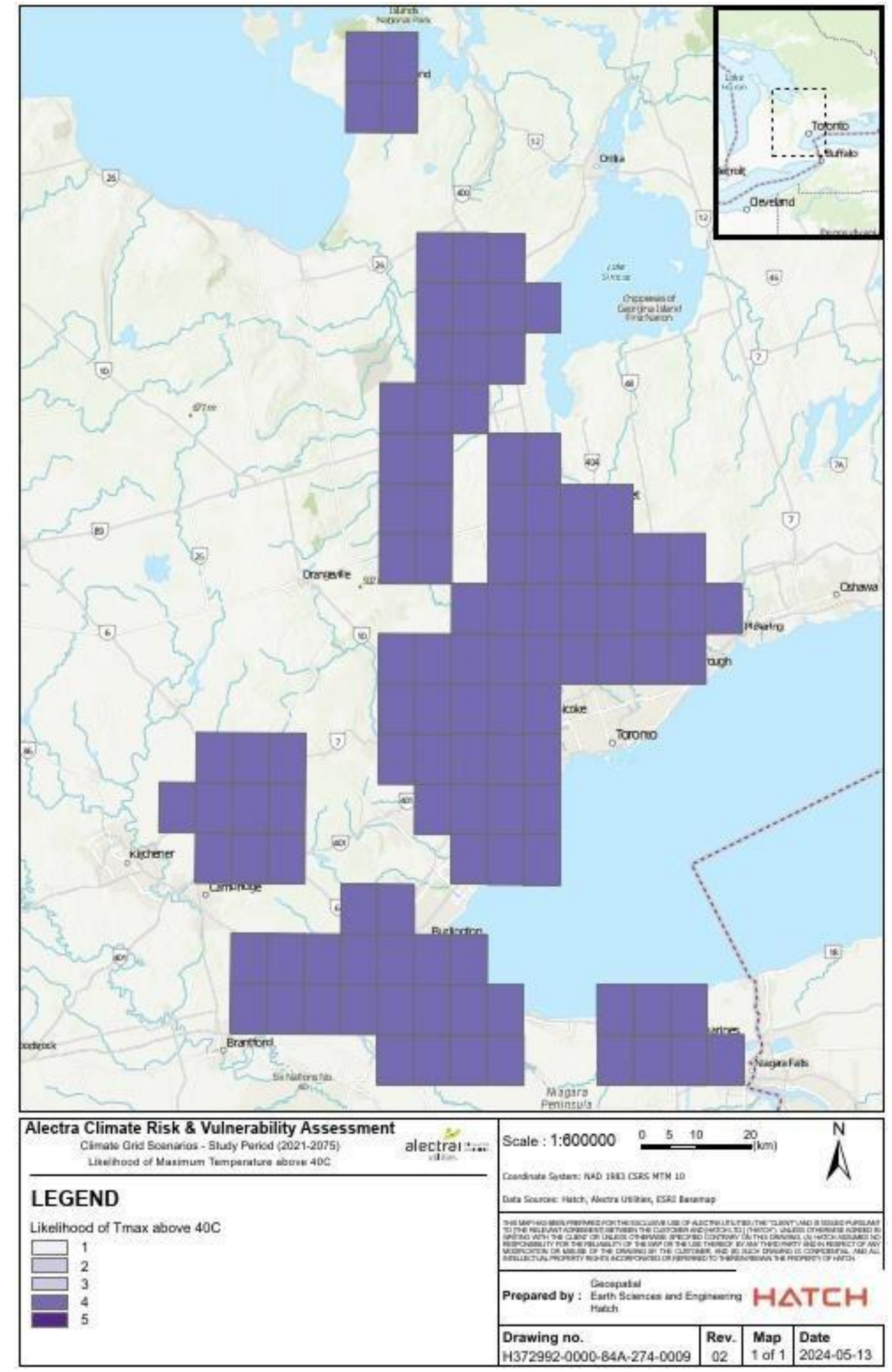


Figure B-2: Likelihood Map for Temperature Above 40°C

B.2 Precipitation

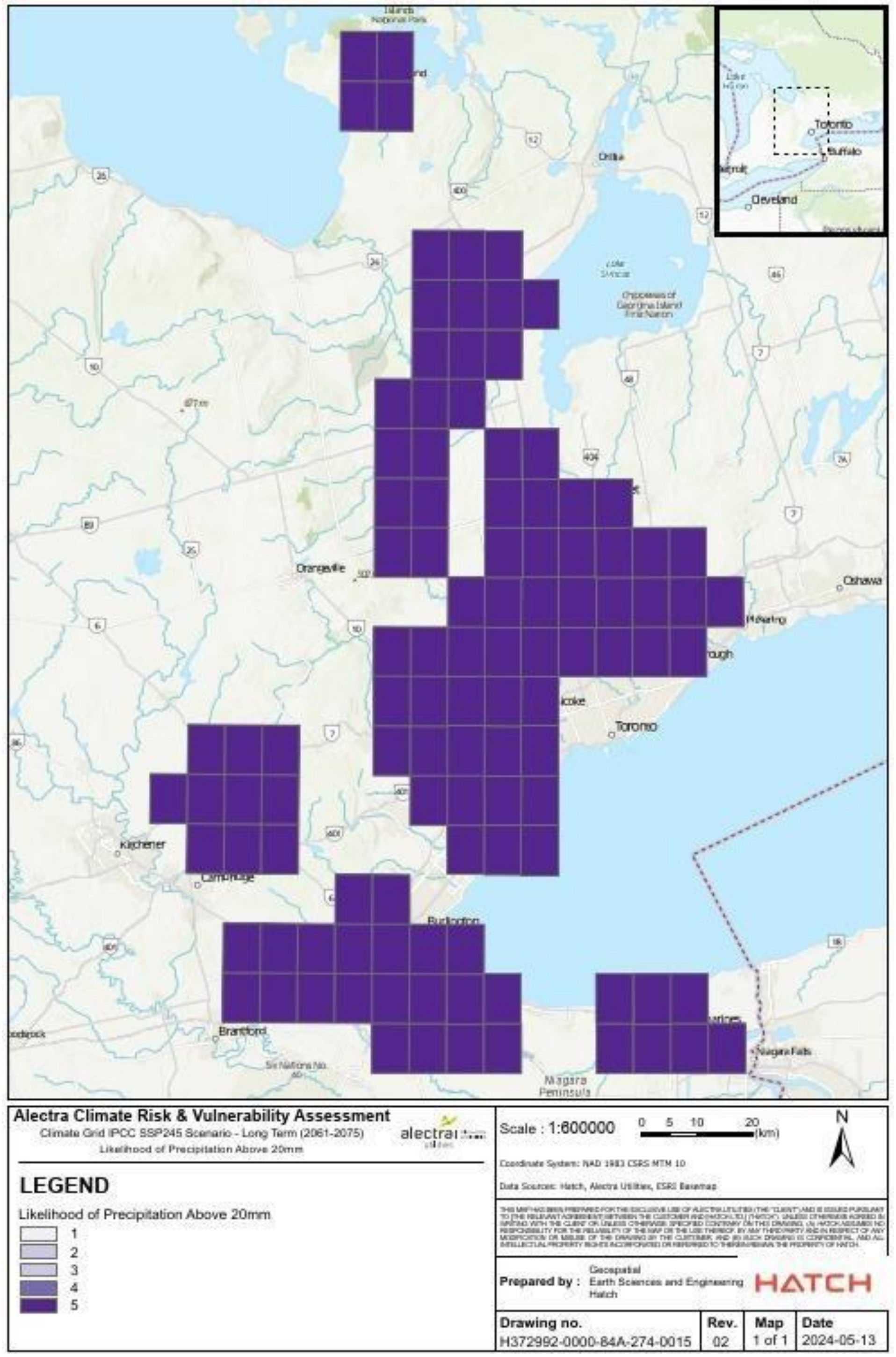


Figure B-3: Likelihood Map for Precipitation above 20 mm

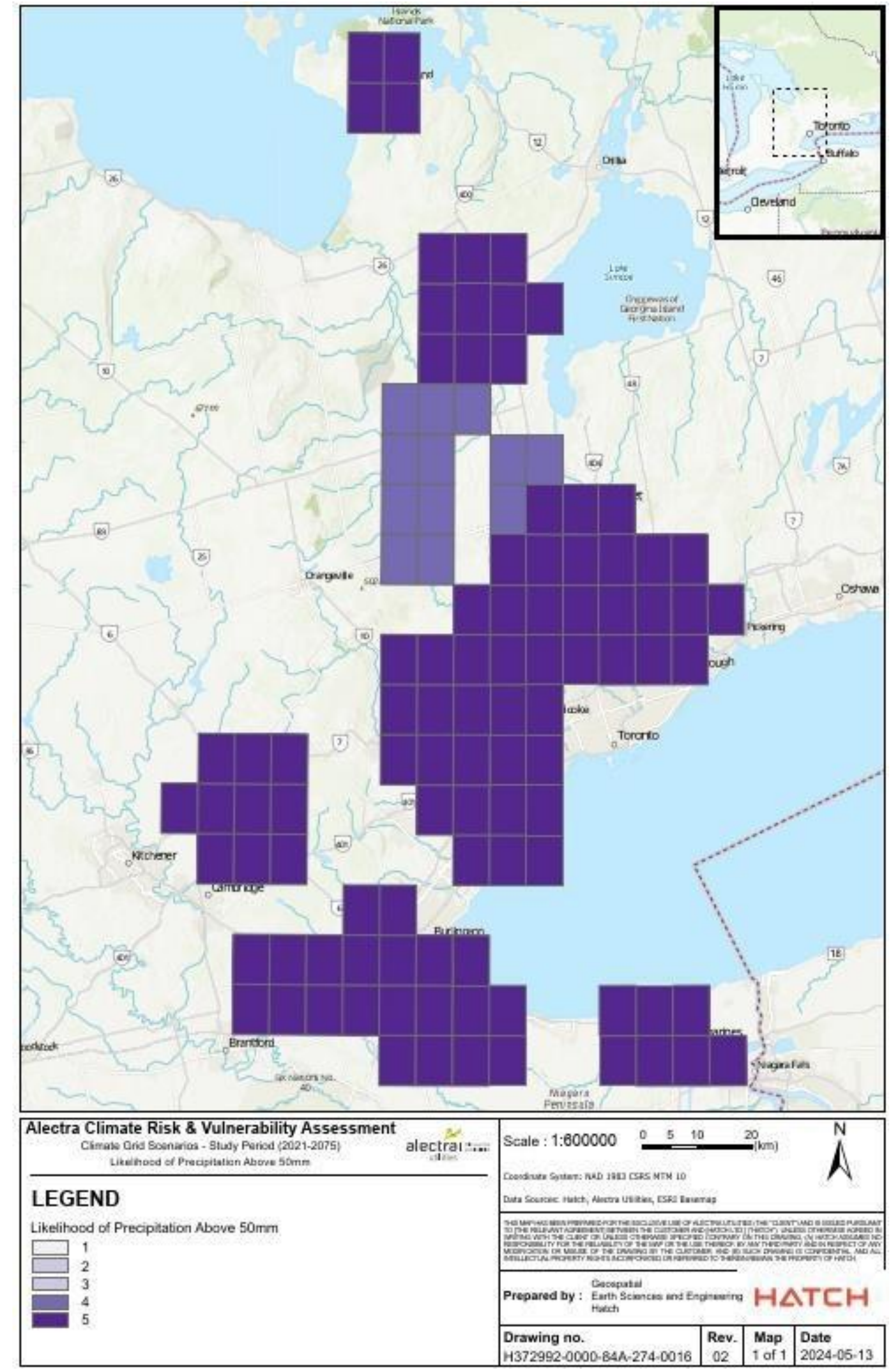


Figure B-4: Likelihood Map for Precipitation above 50 mm

B.3 Wind Gusts

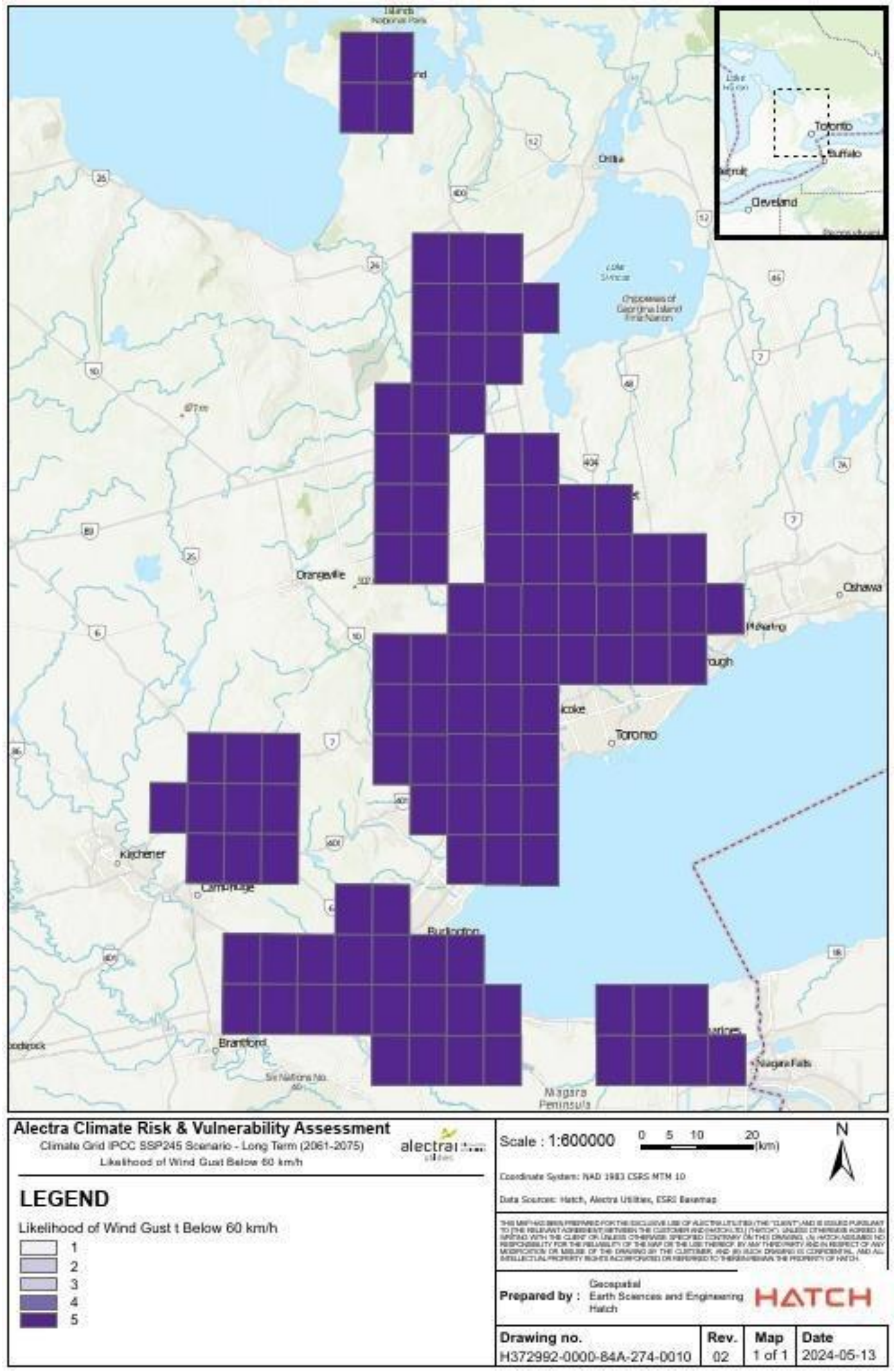


Figure B-5: Likelihood Map for Wind Gusts below 60km/h

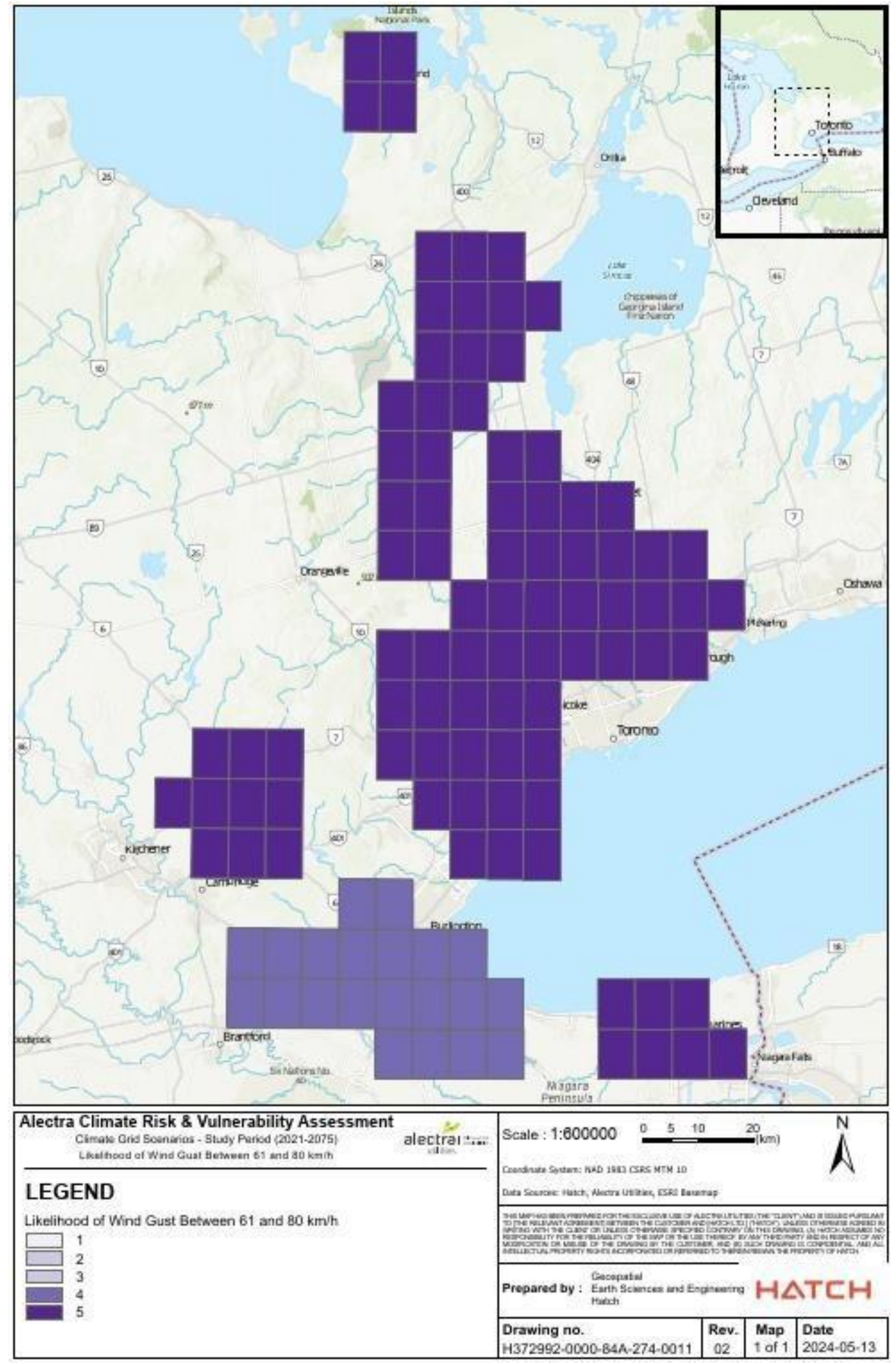


Figure B-6: Likelihood Map for Wind Gusts between 61 and 80km/h

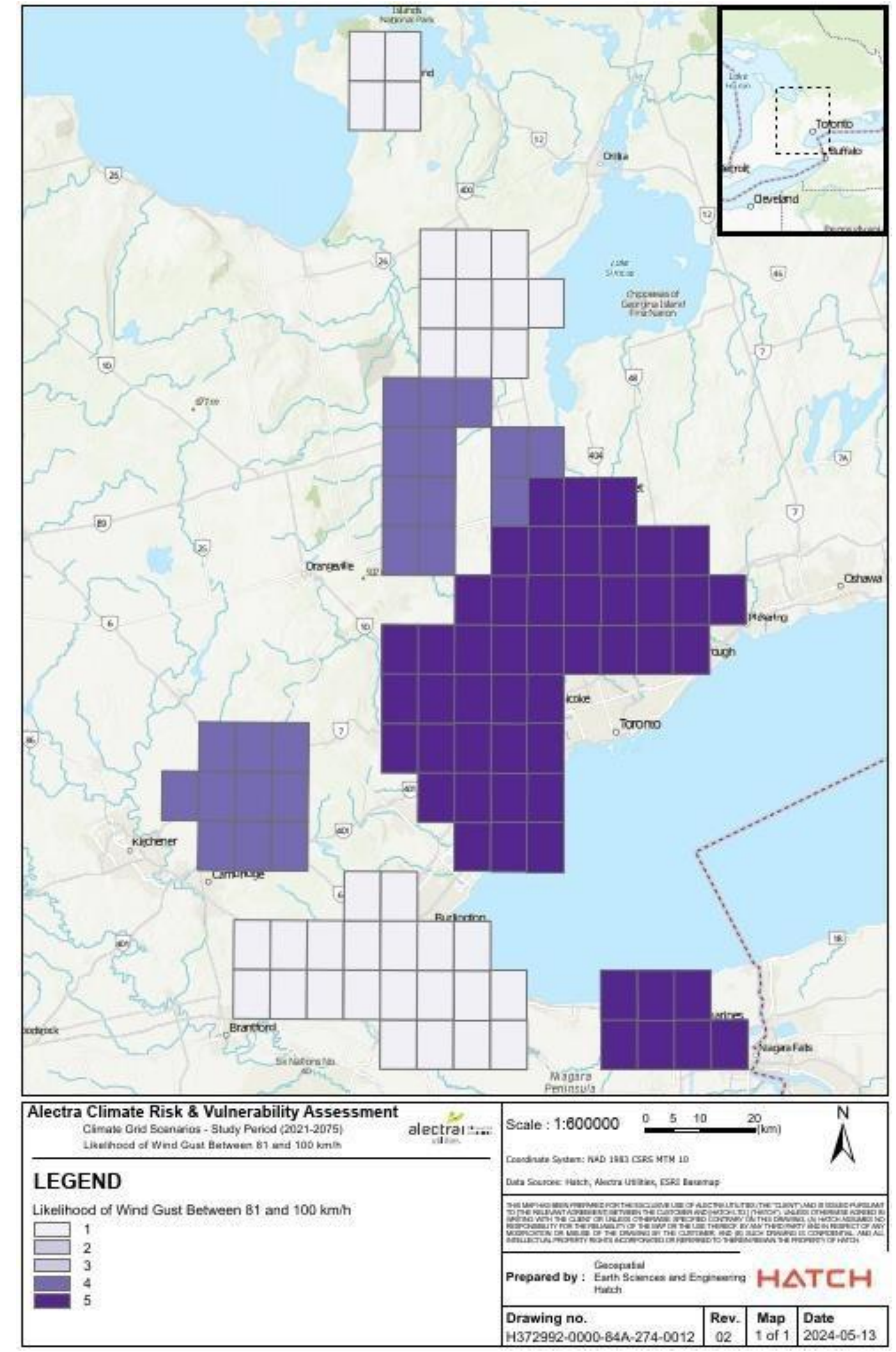


Figure B-7: Likelihood Map for Wind Gusts between 81 and 100km/h

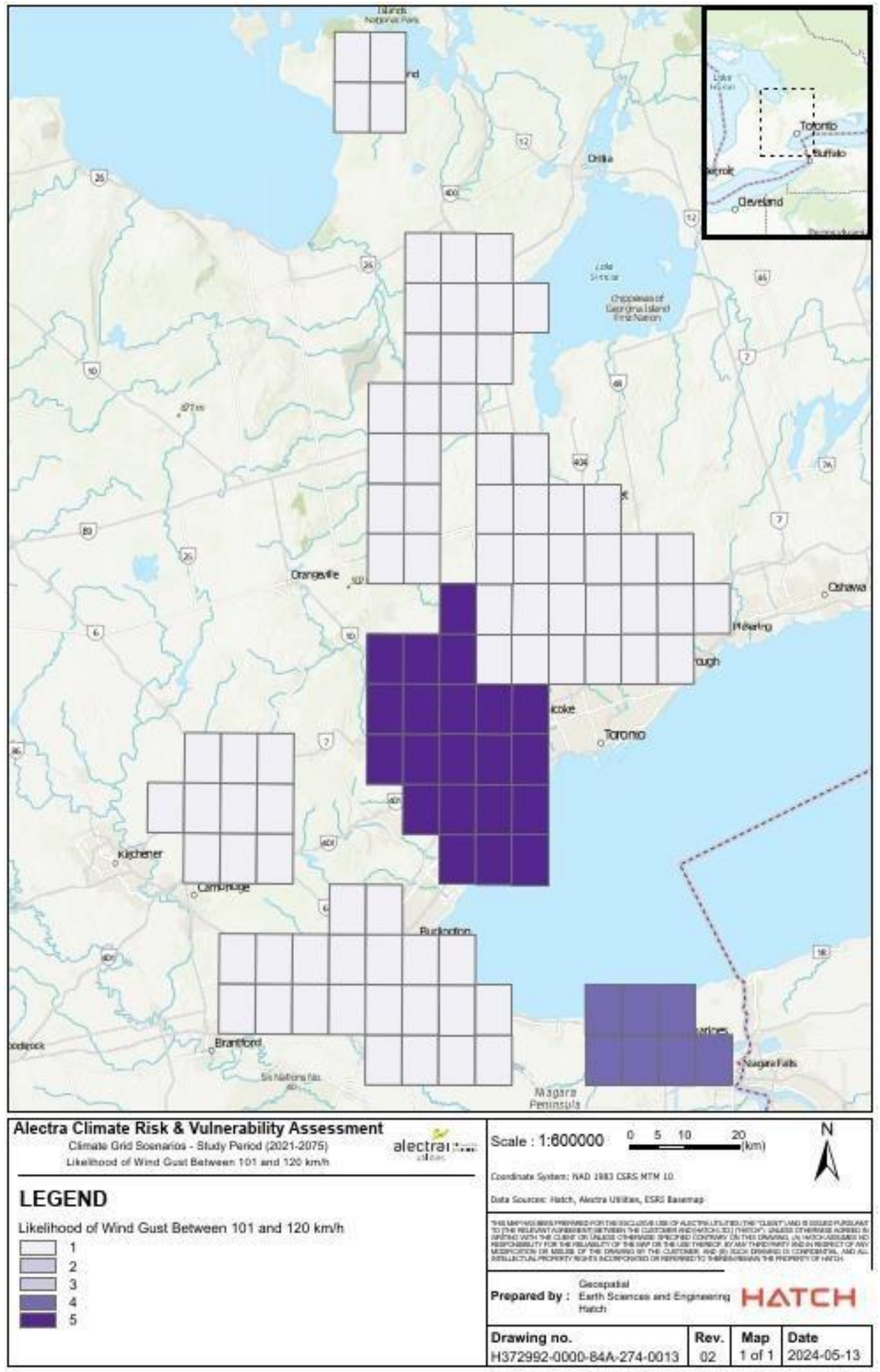


Figure B-8: Likelihood Map for Wind Gusts between 101 and 120 km/h

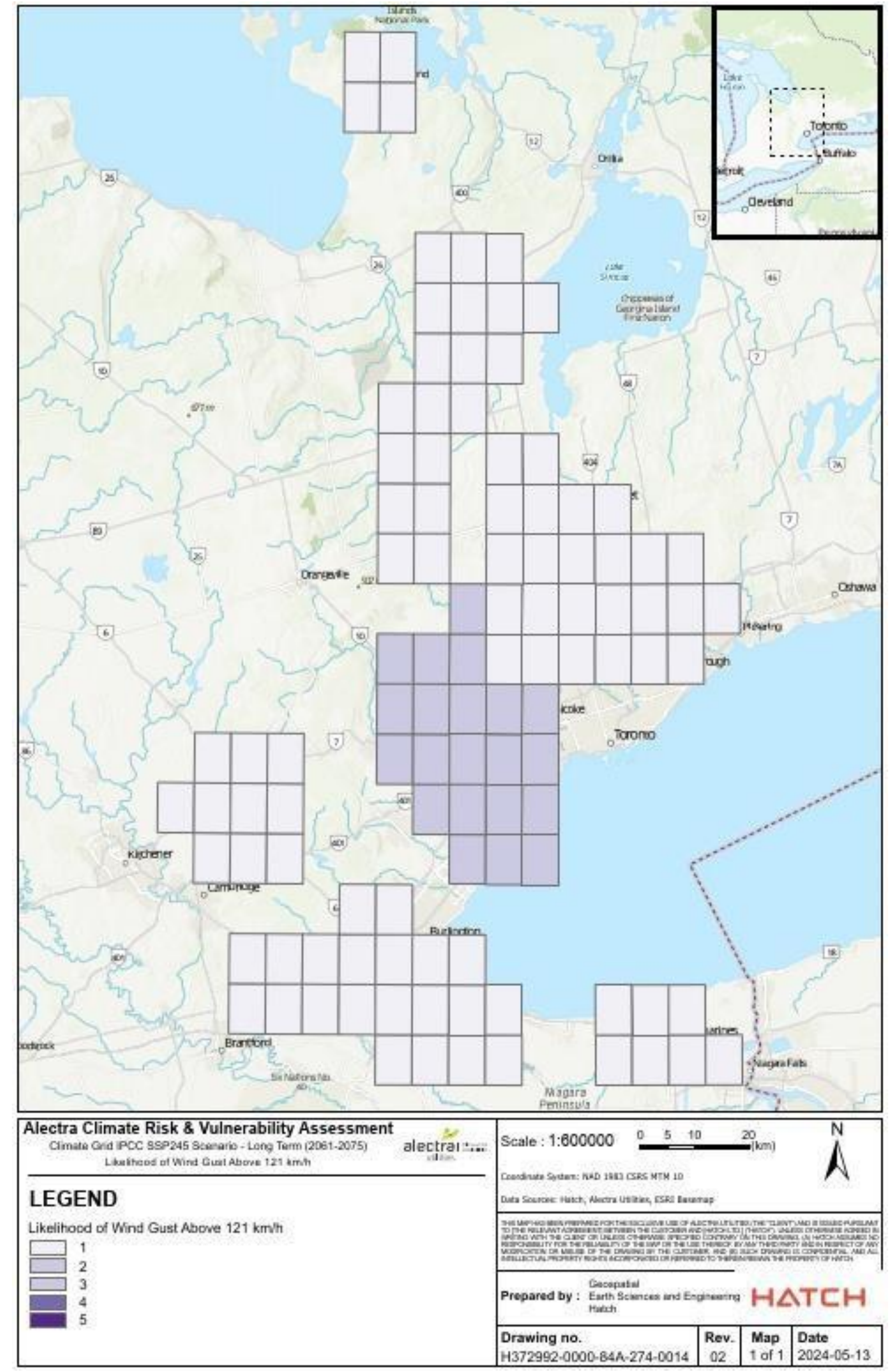


Figure B-9: Likelihood Map for Wind Gusts over 121 km/h

B.4 Extreme Events

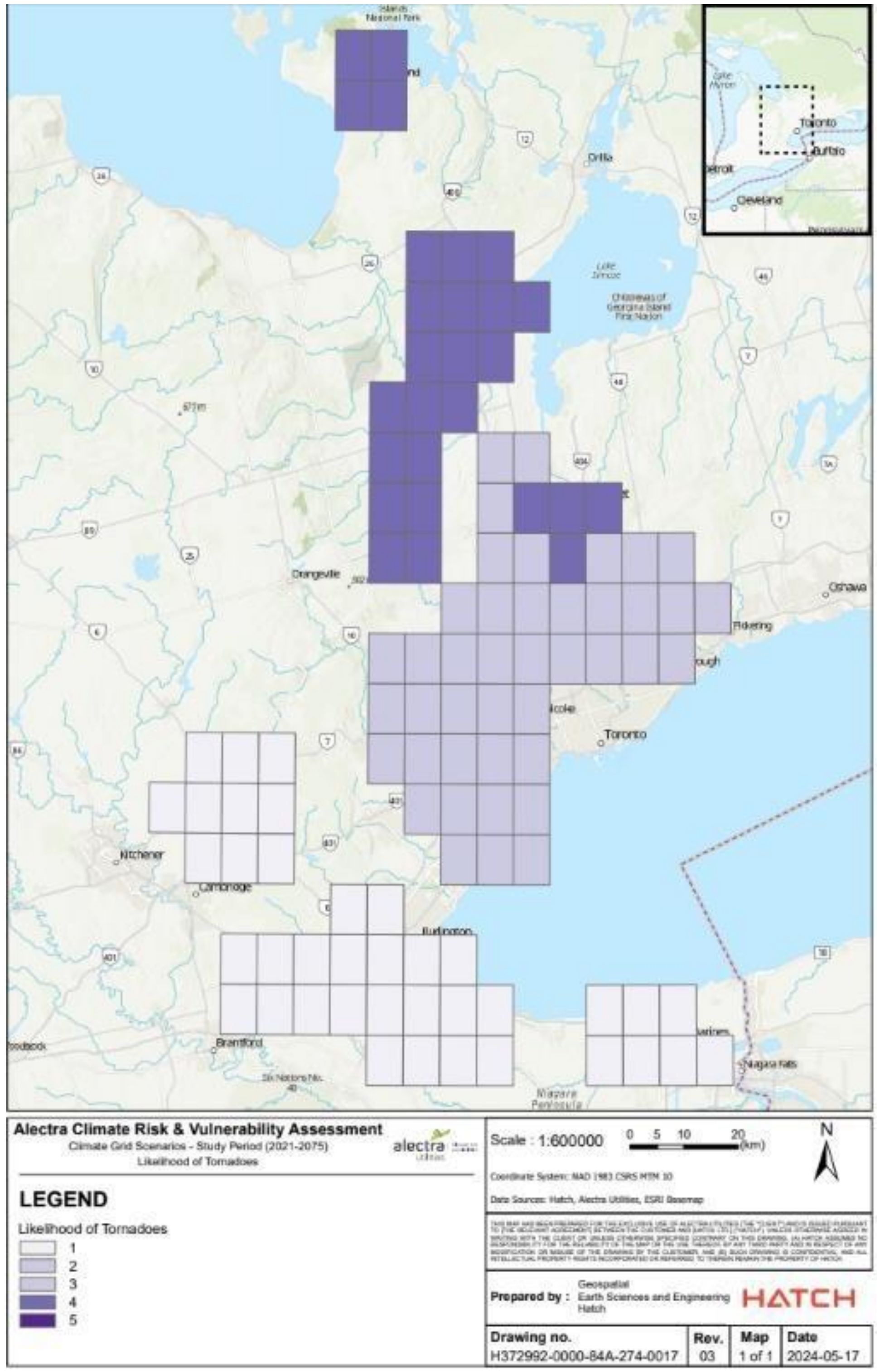


Figure B-10: Likelihood Map for Tornadoes

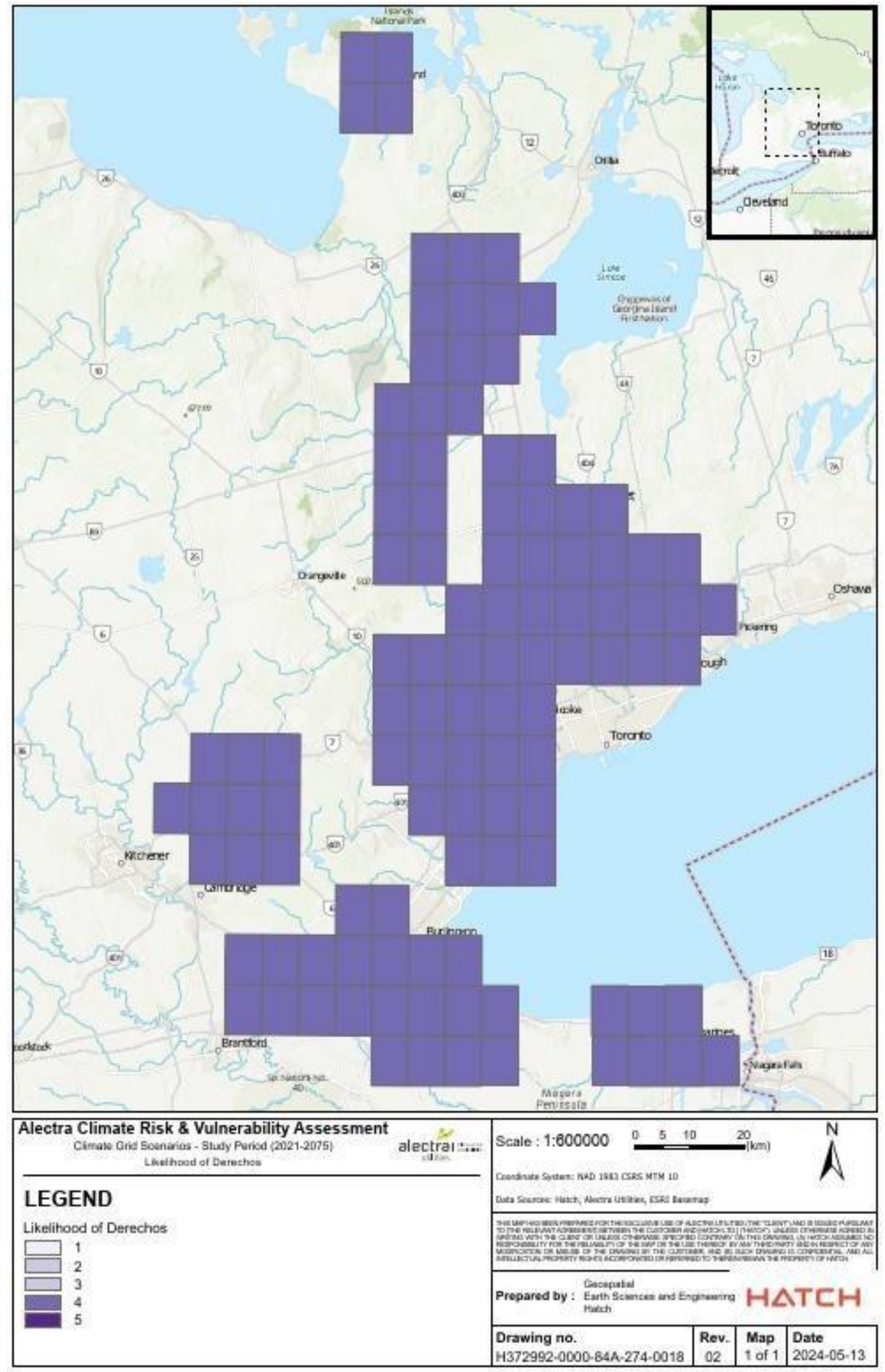


Figure B-11: Likelihood Map for Derechos

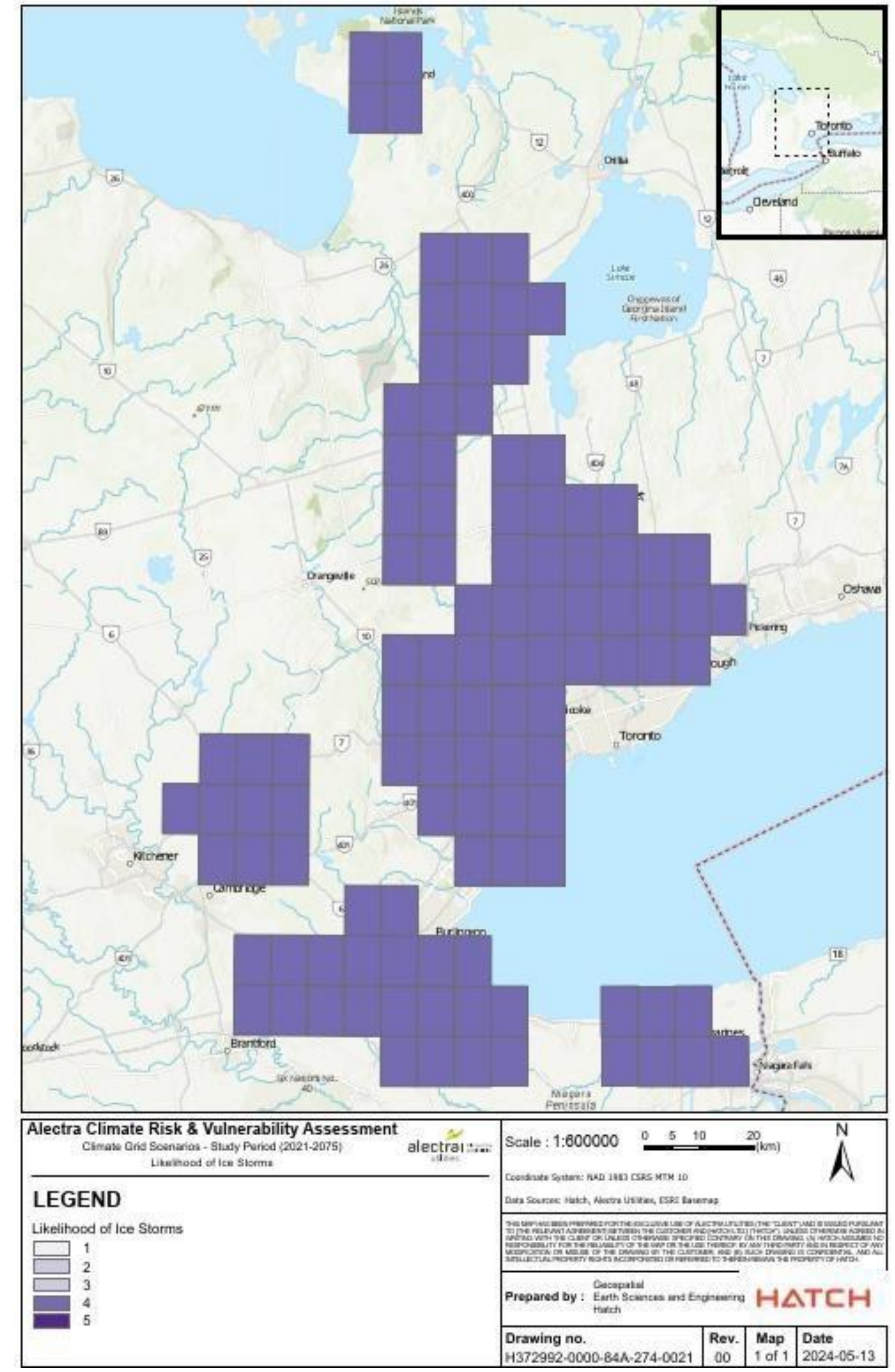


Figure B-12: Likelihood Map for Ice Storms

Appendix C
Risk Profile – Service Zone

Tables C-1 to Table C-3 present the results of the climate analysis as detailed in Section 2, at a Service Zone level. Column 3 of the tables presents the frequency of occurrences of climate parameters, as described in Section 2.4. The results of the risk assessment for each time horizon i.e., Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075) are provided in Columns 4 to 8 respectively. The Likelihood score (L) is calculated based on the standardized probability scoring, as described in Section 2.5. The severity of the climate event is estimated based on the outage analysis, as described in Section 3. The severity score (S) is calculated based on the standardized severity score described in Section 4. The risk score was calculated based on the risk methodology described in Section 4.

Table C-1: Risk Profiles, Service Zone Level, under SSP1-2.6, (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Penetanguishene	Tmax above 32C	5.23	16.68	23.43	24.35	21.22	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Tmax above 40C	-	-	0.01	-	0.00	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Precip above 50mm	0.97	1.10	1.25	0.93	1.11	d/yr	4	1	4	5	1	5	5	1	5	4	1	4	4	1	4
Penetanguishene	Precip above 20mm	9.56	10.65	11.05	10.67	10.80	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Below 60 km/h	360.76	360.74	360.73	360.72	360.73	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 61 and 80 km/h	5.97	6.07	6.10	6.14	6.10	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 81 and 100 km/h	0.70	0.72	0.73	0.73	0.73	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Wind Gust Between 101 and 120 km/h	0.06	0.06	0.06	0.06	0.06	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Penetanguishene	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	1	2	2	1	2	3	1	3	4	1	4	4	1	4
Penetanguishene	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Penetanguishene	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Barrie	Tmax above 32C	8.87	22.21	29.00	31.08	27.10	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Tmax above 40C	-	-	0.18	0.03	0.07	d/yr	1	2	2	1	2	2	4	2	8	2	2	4	3	2	6
Barrie	Precip above 50mm	1.00	1.05	1.10	1.13	1.09	d/yr	4	3	12	5	3	15	5	3	15	5	3	15	5	3	15
Barrie	Precip above 20mm	9.14	10.30	10.65	10.07	10.36	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Barrie	Wind Gust Below 60 km/h	360.79	360.77	360.76	360.76	360.76	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.64	0.64	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	3	3	9	3	3	9	4	3	12	4	3	12	4	3	12
Barrie	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Barrie	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Tmax above 32C	10.15	24.96	32.19	34.20	30.11	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Tmax above 40C	-	0.01	0.31	0.13	0.15	d/yr	1	1	1	1	1	1	4	1	4	3	1	3	3	1	3
Alliston-Thornton	Precip above 50mm	0.94	0.95	1.00	1.00	0.98	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
Alliston-Thornton	Precip above 20mm	8.65	10.00	10.35	9.80	10.07	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.60	360.60	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 61 and 80 km/h	1.73	1.78	1.79	1.81	1.80	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 81 and 100 km/h	0.04	0.05	0.05	0.05	0.05	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Alliston-Thornton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Tornado	0.07	0.09	0.16	0.25	0.13	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Alliston-Thornton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Tmax above 32C	9.19	23.63	30.88	32.85	28.78	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Tmax above 40C	-	-	0.20	0.07	0.09	d/yr	1	1	1	1	1	1	4	1	4	3	1	3	3	1	3
Tottenham-Beeton	Precip above 50mm	0.94	0.95	1.05	1.00	1.00	d/yr	4	1	4	4	1	4	5	1	5	5	1	5	4	1	4
Tottenham-Beeton	Precip above 20mm	9.56	10.65	11.25	10.87	10.93	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.60	360.60	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.64	0.64	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Tottenham-Beeton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tottenham-Beeton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Tottenham-Beeton	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8
Tottenham-Beeton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Bradford	Tmax above 32C	9.65	24.10	31.02	32.76	28.98	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Tmax above 40C	-	-	0.20	0.09	0.10	d/yr	1	1	1	1	1	1	3	1	3	3	1	3	3	1	3
Bradford	Precip above 50mm	0.82	0.90	0.90	0.87	0.89	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Bradford	Precip above 20mm	8.87	10.20	10.70	10.13	10.36	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.60	360.60	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.64	0.64	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Bradford	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Bradford	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Bradford	Tornado	0.04	0.06	0.09	0.15	0.08	events/yr	1	2	2	2	2	4	2	2	4	3	2	6	3	2	6
Bradford	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Bradford	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Aurora	Tmax above 32C	9.17	22.79	29.50	31.33	27.56	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Tmax above 40C	-	-	0.18	0.05	0.08	d/yr	1	1	1	1	1	1	3	1	3	2	1	2	2	1	2
Aurora	Precip above 50mm	0.92	0.95	1.05	1.00	1.00	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Aurora	Precip above 20mm	9.58	11.15	11.35	11.00	11.18	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Below 60 km/h	359.05	358.99	358.97	358.94	358.97	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.23	2.25	2.23	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Aurora	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	3	6	2	3	6	3	3	9	4	3	12	4	3	12
Aurora	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Aurora	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Markham	Tmax above 32C	9.47	23.03	29.64	31.55	27.75	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Markham	Tmax above 40C	-	0.03	0.22	0.17	0.14	d/yr	1	2	2	3	2	6	4	2	8	4	2	8	4	2	8
Markham	Precip above 50mm	1.07	1.10	1.25	1.07	1.15	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Precip above 20mm	10.30	11.85	11.95	12.07	11.95	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Markham	Wind Gust Below 60 km/h	359.05	358.99	358.97	358.94	358.97	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.23	2.25	2.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Markham	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Markham	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Richmond Hill	Tmax above 32C	11.01	25.65	32.50	34.73	30.62	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Richmond Hill	Tmax above 40C	-	0.10	0.35	0.33	0.25	d/yr	1	2	2	2	2	4	4	2	8	4	2	8	4	2	8
Richmond Hill	Precip above 50mm	1.03	1.10	1.15	1.07	1.11	d/yr	4	3	12	5	3	15	4	3	12	5	3	15	4	3	12
Richmond Hill	Precip above 20mm	9.83	11.25	11.50	11.07	11.29	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Richmond Hill	Wind Gust Below 60 km/h	359.05	358.99	358.97	358.94	358.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.23	2.25	2.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Richmond Hill	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Richmond Hill	Tornado	0.01	0.02	0.03	0.05	0.03	events/yr	1	3	3	2	3	6	2	3	6	2	3	6	2	3	6
Richmond Hill	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Richmond Hill	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Vaughan	Tmax above 32C	11.03	25.88	32.81	35.32	30.98	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Tmax above 40C	-	0.05	0.39	0.30	0.24	d/yr	1	3	3	2	3	6	4	3	12	4	3	12	4	3	12
Vaughan	Precip above 50mm	1.10	1.10	1.20	1.13	1.15	d/yr	5	3	15	5	3	15	4	3	12	5	3	15	4	3	12
Vaughan	Precip above 20mm	9.89	11.55	11.85	11.13	11.55	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Below 60 km/h	359.05	358.99	358.97	358.94	358.97	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.88	12.95	12.88	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.50	1.51	1.50	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.10	0.11	0.10	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Vaughan	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Vaughan	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Brampton	Tmax above 32C	10.79	25.60	32.96	35.49	30.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Tmax above 40C	-	0.05	0.32	0.17	0.18	d/yr	1	3	3	2	3	6	4	3	12	4	3	12	4	3	12
Brampton	Precip above 50mm	1.13	1.15	1.40	1.27	1.27	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Precip above 20mm	10.37	11.70	12.40	11.87	12.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Brampton	Wind Gust Below 60 km/h	347.10	346.85	346.76	346.68	346.76	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Brampton	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.88	12.95	12.88	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Brampton	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.50	1.51	1.50	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Brampton	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.10	0.11	0.10	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Brampton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Brampton	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Brampton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Brampton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Mississauga	Tmax above 32C	11.91	26.45	33.06	35.48	31.31	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Tmax above 40C	-	0.12	0.50	0.42	0.34	d/yr	1	3	3	3	3	9	4	3	12	4	3	12	4	3	12
Mississauga	Precip above 50mm	1.17	1.25	1.50	1.53	1.42	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Precip above 20mm	10.30	11.65	12.20	11.93	11.93	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Below 60 km/h	347.10	346.85	346.76	346.68	346.76	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Mississauga	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.88	12.95	12.88	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.50	1.51	1.50	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.10	0.11	0.10	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Mississauga	Tornado	0.19	0.26	0.43	0.70	0.37	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Mississauga	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Mississauga	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Guelph-Rockwood	Tmax above 32C	7.05	20.13	27.37	28.84	25.14	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Tmax above 40C	-	0.03	0.10	0.05	0.06	d/yr	1	3	3	1	3	3	3	3	9	3	3	9	3	3	9
Guelph-Rockwood	Precip above 50mm	1.01	1.05	1.30	1.27	1.20	d/yr	5	2	10	5	2	10	4	2	8	5	2	10	4	2	8
Guelph-Rockwood	Precip above 20mm	10.37	11.80	12.30	12.00	12.04	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Below 60 km/h	360.51	360.49	360.48	360.47	360.48	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Between 61 and 80 km/h	8.90	9.06	9.12	9.18	9.12	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Guelph-Rockwood	Wind Gust Between 81 and 100 km/h	0.78	0.81	0.82	0.82	0.82	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Wind Gust Between 101 and 120 km/h	0.04	0.04	0.04	0.04	0.04	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Tmax above 32C	11.39	26.84	33.89	36.94	32.16	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Tmax above 40C	-	0.10	0.38	0.34	0.27	d/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Hamilton	Precip above 50mm	1.04	1.10	1.30	1.33	1.24	d/yr	4	4	16	5	4	20	5	4	20	5	4	20	5	4	20
Hamilton	Precip above 20mm	10.90	12.30	12.85	12.93	12.67	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Wind Gust Between 61 and 80 km/h	12.68	12.90	12.97	13.04	12.97	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Wind Gust Between 81 and 100 km/h	1.33	1.37	1.39	1.40	1.39	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Hamilton	Wind Gust Between 101 and 120 km/h	0.08	0.08	0.08	0.08	0.08	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Tornado	0.29	0.39	0.65	1.05	0.55	events/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Hamilton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
St. Catharines	Tmax above 32C	10.03	26.09	33.31	36.48	31.55	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Tmax above 40C	-	0.01	0.09	0.11	0.07	d/yr	1	2	2	1	2	2	3	2	6	4	2	8	3	2	6
St. Catharines	Precip above 50mm	1.00	1.05	1.00	1.13	1.05	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
St. Catharines	Precip above 20mm	10.42	11.60	12.15	12.13	11.95	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Below 60 km/h	356.93	356.83	356.80	356.76	356.80	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Between 61 and 80 km/h	15.70	15.95	16.03	16.11	16.15	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 81 and 100 km/h	1.89	1.94	1.96	1.98	1.98	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 101 and 120 km/h	0.13	0.13	0.14	0.14	0.14	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Wind Gust Over 121 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12

Table C-2: Risk Profile Service Zone Level, under SSP2-4.5, (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Penetanguishene	Tmax above 32C	5.05	18.23	26.06	35.12	25.68	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Tmax above 40C	-	-	0.05	0.15	0.06	d/yr	1	1	1	1	1	1	1	1	1	4	1	4	2	1	2
Penetanguishene	Precip above 50mm	0.96	1.00	1.10	1.13	1.07	d/yr	4	1	4	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Precip above 20mm	9.54	10.65	11.05	12.33	11.25	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Below 60 km/h	360.76	360.74	360.72	360.70	360.72	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 61 and 80 km/h	5.97	6.07	6.14	6.24	6.15	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 81 and 100 km/h	0.70	0.72	0.73	0.75	0.74	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Wind Gust Between 101 and 120 km/h	0.06	0.06	0.06	0.07	0.06	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Penetanguishene	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	1	2	2	1	2	3	1	3	4	1	4	4	1	4
Penetanguishene	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Penetanguishene	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Barrie	Tmax above 32C	8.64	23.17	31.94	42.37	31.59	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Tmax above 40C	-	-	0.12	0.51	0.18	d/yr	1	2	2	1	2	2	3	2	6	4	2	8	3	2	6
Barrie	Precip above 50mm	0.97	1.15	1.10	1.27	1.16	d/yr	4	3	12	5	3	15	5	3	15	4	3	12	4	3	12
Barrie	Precip above 20mm	9.20	10.15	10.40	11.53	10.62	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Barrie	Wind Gust Below 60 km/h	360.79	360.77	360.76	360.73	360.75	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.67	0.65	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	3	3	9	3	3	9	4	3	12	4	3	12	4	3	12
Barrie	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Barrie	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Tmax above 32C	9.85	25.62	35.73	45.97	34.85	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Tmax above 40C	-	0.02	0.13	0.76	0.26	d/yr	1	1	1	1	1	1	3	1	3	4	1	4	4	1	4
Alliston-Thornton	Precip above 50mm	0.94	1.05	1.00	1.00	1.02	d/yr	4	2	8	5	2	10	5	2	10	4	2	8	4	2	8
Alliston-Thornton	Precip above 20mm	8.72	9.75	10.15	10.87	10.20	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.57	360.59	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 61 and 80 km/h	1.73	1.78	1.81	1.86	1.83	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 81 and 100 km/h	0.04	0.05	0.05	0.05	0.05	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Alliston-Thornton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Tornado	0.07	0.09	0.16	0.25	0.13	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8
Alliston-Thornton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Tmax above 32C	8.90	24.69	34.44	44.52	33.64	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Tottenham-Beeton	Tmax above 40C	-	-	0.10	0.50	0.17	d/yr	1	1	1	1	1	1	2	1	2	4	1	4	3	1	3
Tottenham-Beeton	Precip above 50mm	0.93	1.05	1.15	1.07	1.09	d/yr	4	1	4	4	1	4	5	1	5	4	1	4	4	1	4
Tottenham-Beeton	Precip above 20mm	9.56	10.35	11.05	11.60	10.95	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.57	360.59	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.67	0.65	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Tottenham-Beeton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tottenham-Beeton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Tottenham-Beeton	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8
Tottenham-Beeton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Bradford	Tmax above 32C	9.36	24.63	34.63	44.56	33.70	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Tmax above 40C	-	0.02	0.10	0.58	0.20	d/yr	1	1	1	1	1	1	2	1	2	4	1	4	3	1	3
Bradford	Precip above 50mm	0.82	0.90	1.05	0.93	0.96	d/yr	4	2	8	4	2	8	5	2	10	4	2	8	4	2	8
Bradford	Precip above 20mm	8.90	10.20	10.60	11.07	10.58	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Below 60 km/h	360.63	360.61	360.60	360.57	360.59	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 61 and 80 km/h	0.61	0.63	0.64	0.67	0.65	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Bradford	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Bradford	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Bradford	Tornado	0.04	0.06	0.09	0.15	0.08	events/yr	1	2	2	2	2	4	2	2	4	3	2	6	3	2	6
Bradford	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Bradford	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Aurora	Tmax above 32C	8.87	23.33	32.74	42.63	32.01	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Tmax above 40C	-	-	0.10	0.52	0.18	d/yr	1	1	1	1	1	1	2	1	2	4	1	4	3	1	3
Aurora	Precip above 50mm	0.92	0.95	1.15	1.00	1.04	d/yr	4	2	8	4	2	8	5	2	10	4	2	8	4	2	8
Aurora	Precip above 20mm	9.59	10.90	11.20	12.13	11.35	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Below 60 km/h	359.05	358.99	358.94	358.88	358.94	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.25	2.31	2.26	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Aurora	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	3	6	2	3	6	3	3	9	4	3	12	4	3	12
Aurora	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Aurora	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Markham	Tmax above 32C	9.23	23.73	33.31	42.88	32.43	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Tmax above 40C	-	0.02	0.19	0.84	0.30	d/yr	1	2	2	3	2	6	4	2	8	4	2	8	4	2	8
Markham	Precip above 50mm	1.07	1.25	1.40	1.47	1.36	d/yr	5	2	10	4	2	8	5	2	10	5	2	10	4	2	8
Markham	Precip above 20mm	10.28	11.80	12.10	12.93	12.22	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Markham	Wind Gust Below 60 km/h	359.05	358.99	358.94	358.88	358.94	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.25	2.31	2.26	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Markham	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Markham	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Richmond Hill	Tmax above 32C	10.79	26.35	36.45	46.00	35.38	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Richmond Hill	Tmax above 40C	-	0.05	0.25	1.20	0.44	d/yr	1	2	2	1	2	2	3	2	6	4	2	8	4	2	8
Richmond Hill	Precip above 50mm	1.03	0.95	1.30	1.00	1.09	d/yr	4	3	12	4	3	12	5	3	15	4	3	12	4	3	12
Richmond Hill	Precip above 20mm	9.75	10.95	11.25	12.00	11.35	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Richmond Hill	Wind Gust Below 60 km/h	359.05	358.99	358.94	358.88	358.94	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 61 and 80 km/h	2.14	2.21	2.25	2.31	2.26	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 81 and 100 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Richmond Hill	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Richmond Hill	Tornado	0.01	0.02	0.03	0.05	0.03	events/yr	1	3	3	2	3	6	2	3	6	2	3	6	2	3	6
Richmond Hill	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Richmond Hill	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Vaughan	Tmax above 32C	10.76	26.61	36.59	46.64	35.70	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Tmax above 40C	-	0.06	0.26	1.27	0.46	d/yr	1	3	3	2	3	6	4	3	12	4	3	12	4	3	12
Vaughan	Precip above 50mm	1.07	1.10	1.25	1.00	1.13	d/yr	5	3	15	4	3	12	5	3	15	5	3	15	4	3	12
Vaughan	Precip above 20mm	9.86	11.15	11.60	12.40	11.65	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Below 60 km/h	359.05	358.99	358.94	358.88	358.94	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.95	13.16	12.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.51	1.56	1.52	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.11	0.11	0.11	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Vaughan	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Vaughan	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Brampton	Tmax above 32C	10.53	26.71	36.90	47.08	35.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Tmax above 40C	-	0.03	0.23	1.15	0.41	d/yr	1	3	3	2	3	6	4	3	12	4	3	12	4	3	12
Brampton	Precip above 50mm	1.08	1.15	1.20	1.67	1.31	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Precip above 20mm	10.38	11.95	12.00	12.33	12.07	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Wind Gust Below 60 km/h	347.10	346.85	346.68	346.42	346.65	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Brampton	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.95	13.16	12.97	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Brampton	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.51	1.56	1.52	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Brampton	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.11	0.11	0.11	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Brampton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Brampton	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Brampton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Brampton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Mississauga	Tmax above 32C	11.67	27.88	36.81	47.08	36.36	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Tmax above 40C	-	0.16	0.39	1.51	0.61	d/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Mississauga	Precip above 50mm	1.13	1.20	1.40	1.60	1.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Precip above 20mm	10.27	12.00	12.10	12.53	12.18	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Below 60 km/h	347.10	346.85	346.68	346.42	346.65	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Mississauga	Wind Gust Between 61 and 80 km/h	12.61	12.81	12.95	13.16	12.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Between 81 and 100 km/h	1.44	1.49	1.51	1.56	1.52	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Between 101 and 120 km/h	0.10	0.10	0.11	0.11	0.11	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Mississauga	Tornado	0.19	0.26	0.43	0.70	0.37	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Mississauga	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Mississauga	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Guelph-Rockwood	Tmax above 32C	6.87	20.90	30.66	41.13	29.96	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Tmax above 40C	-	0.01	0.06	0.32	0.11	d/yr	1	3	3	1	3	3	2	3	6	4	3	12	4	3	12
Guelph-Rockwood	Precip above 50mm	1.01	1.10	1.15	1.53	1.24	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Precip above 20mm	10.37	12.25	12.50	12.67	12.45	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Below 60 km/h	360.51	360.49	360.47	360.44	360.47	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Between 61 and 80 km/h	8.90	9.06	9.18	9.34	9.20	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Guelph-Rockwood	Wind Gust Between 81 and 100 km/h	0.78	0.81	0.82	0.85	0.83	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Wind Gust Between 101 and 120 km/h	0.04	0.04	0.04	0.04	0.04	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Tmax above 32C	11.20	28.18	38.23	48.90	37.48	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Tmax above 40C	-	0.14	0.37	1.05	0.47	d/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Hamilton	Precip above 50mm	1.06	1.20	1.40	1.47	1.35	d/yr	4	4	16	5	4	20	5	4	20	5	4	20	5	4	20
Hamilton	Precip above 20mm	10.87	12.85	13.10	13.67	13.16	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Wind Gust Between 61 and 80 km/h	12.68	12.90	13.04	13.26	13.06	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Wind Gust Between 81 and 100 km/h	1.33	1.37	1.40	1.44	1.41	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Hamilton	Wind Gust Between 101 and 120 km/h	0.08	0.08	0.08	0.09	0.08	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Tornado	0.29	0.39	0.65	1.05	0.55	events/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Hamilton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Hamilton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
St. Catharines	Tmax above 32C	9.82	27.42	37.83	49.15	37.13	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Tmax above 40C	-	0.01	0.08	0.31	0.12	d/yr	1	2	2	1	2	2	3	2	6	4	2	8	4	2	8
St. Catharines	Precip above 50mm	1.00	1.15	1.15	1.13	1.15	d/yr	4	2	8	5	2	10	5	2	10	5	2	10	5	2	10
St. Catharines	Precip above 20mm	10.42	11.85	12.40	12.87	12.33	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Below 60 km/h	356.93	356.83	356.76	356.66	356.76	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Between 61 and 80 km/h	15.70	15.95	16.11	16.36	16.26	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 81 and 100 km/h	1.89	1.94	1.98	2.03	2.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 101 and 120 km/h	0.13	0.13	0.14	0.14	0.14	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Wind Gust Over 121 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12

Table C-3: Risk Profile Service Zone Level, under SSP5-8.5, (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Penetanguishene	Tmax above 32C	5.46	18.76	36.29	58.82	36.06	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Tmax above 40C	-	-	0.16	2.38	0.71	d/yr	1	1	1	1	1	1	3	1	3	4	1	4	4	1	4
Penetanguishene	Precip above 50mm	0.94	1.00	1.15	1.33	1.15	d/yr	4	1	4	4	1	4	5	1	5	5	1	5	4	1	4
Penetanguishene	Precip above 20mm	9.61	11.45	12.10	12.53	11.98	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Below 60 km/h	360.76	360.71	360.71	360.62	360.67	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 61 and 80 km/h	5.97	6.17	6.17	6.55	6.34	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Penetanguishene	Wind Gust Between 81 and 100 km/h	0.70	0.74	0.74	0.81	0.77	d/yr	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
Penetanguishene	Wind Gust Between 101 and 120 km/h	0.06	0.06	0.06	0.07	0.07	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Penetanguishene	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.01	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Penetanguishene	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	1	2	2	1	2	3	1	3	4	1	4	4	1	4
Penetanguishene	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Penetanguishene	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Barrie	Tmax above 32C	9.07	24.33	44.30	66.12	42.99	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Tmax above 40C	0.01	0.04	0.73	4.25	1.44	d/yr	1	2	2	2	2	4	4	2	8	5	2	10	4	2	8
Barrie	Precip above 50mm	1.00	1.20	1.20	1.27	1.22	d/yr	4	3	12	5	3	15	5	3	15	5	3	15	5	3	15
Barrie	Precip above 20mm	9.23	10.60	11.60	12.07	11.36	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Barrie	Wind Gust Below 60 km/h	360.79	360.75	360.75	360.67	360.71	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 61 and 80 km/h	0.61	0.65	0.65	0.73	0.69	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Barrie	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	2	3	6	1	3	3
Barrie	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Barrie	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	3	3	9	3	3	9	4	3	12	4	3	12	4	3	12
Barrie	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Barrie	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Tmax above 32C	10.39	27.14	48.33	69.59	46.42	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Tmax above 40C	0.01	0.10	1.00	4.77	1.70	d/yr	1	1	1	2	1	2	4	1	4	5	1	5	4	1	4
Alliston-Thornton	Precip above 50mm	0.94	1.00	0.95	1.13	1.02	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
Alliston-Thornton	Precip above 20mm	8.69	10.10	10.95	11.60	10.82	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Below 60 km/h		360.59	360.59	360.50	360.55	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 61 and 80 km/h	1.73	1.83	1.83	2.03	1.93	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Alliston-Thornton	Wind Gust Between 81 and 100 km/h	0.04	0.05	0.05	0.06	0.05	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Alliston-Thornton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Alliston-Thornton	Tornado	0.07	0.09	0.16	0.25	0.13	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8
Alliston-Thornton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Alliston-Thornton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Tmax above 32C	9.42	25.94	47.06	68.30	45.17	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Tottenham-Beeton	Tmax above 40C	0.01	0.08	0.85	4.22	1.49	d/yr	1	1	1	2	1	2	4	1	4	5	1	5	4	1	4
Tottenham-Beeton	Precip above 50mm	0.93	0.95	1.00	1.13	1.02	d/yr	4	1	4	4	1	4	5	1	5	5	1	5	4	1	4
Tottenham-Beeton	Precip above 20mm	9.58	10.75	11.70	12.33	11.53	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Below 60 km/h	360.63	360.59	360.59	360.50	360.55	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 61 and 80 km/h	0.61	0.65	0.65	0.73	0.69	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Tottenham-Beeton	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Tottenham-Beeton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tottenham-Beeton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Tottenham-Beeton	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	2	4	2	2	4	3	2	6	4	2	8	4	2	8
Tottenham-Beeton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	2	2	4	2	8	4	2	8	4	2	8	4	2	8
Tottenham-Beeton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Bradford	Tmax above 32C	9.88	25.95	47.05	68.42	45.21	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Tmax above 40C	0.01	0.07	0.88	4.42	1.55	d/yr	1	1	1	2	1	2	4	1	4	5	1	5	4	1	4
Bradford	Precip above 50mm	0.80	0.95	0.90	1.07	0.96	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
Bradford	Precip above 20mm	8.93	10.30	11.05	11.73	10.96	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Below 60 km/h	360.63	360.59	360.59	360.50	360.55	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 61 and 80 km/h	0.61	0.65	0.65	0.73	0.69	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Bradford	Wind Gust Between 81 and 100 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Bradford	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Bradford	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Bradford	Tornado	0.04	0.06	0.09	0.15	0.08	events/yr	1	2	2	2	2	4	2	2	4	3	2	6	3	2	6
Bradford	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Bradford	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	2	8	4	2	8	4	2	8	4	2	8	4	2	8
Aurora	Tmax above 32C	9.34	24.51	45.13	66.57	43.48	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Tmax above 40C	0.01	0.06	0.85	4.27	1.50	d/yr	1	1	1	3	1	3	4	1	4	5	1	5	4	1	4
Aurora	Precip above 50mm	0.92	1.10	1.00	1.07	1.05	d/yr	4	2	8	5	2	10	5	2	10	5	2	10	5	2	10
Aurora	Precip above 20mm	9.62	11.00	11.70	12.73	11.73	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Below 60 km/h	359.05	358.92	358.92	358.66	358.81	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 61 and 80 km/h	2.14	2.27	2.27	2.52	2.38	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Aurora	Wind Gust Between 81 and 100 km/h	0.05	0.06	0.06	0.07	0.06	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Aurora	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Aurora	Tornado	0.05	0.07	0.12	0.20	0.11	events/yr	2	3	6	2	3	6	3	3	9	4	3	12	4	3	12
Aurora	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Aurora	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Markham	Tmax above 32C	9.70	25.06	45.67	67.06	44.01	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Tmax above 40C	0.01	0.13	1.22	4.61	1.75	d/yr	1	2	2	4	2	8	4	2	8	5	2	10	4	2	8
Markham	Precip above 50mm	1.07	1.25	1.40	1.40	1.35	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Precip above 20mm	10.35	11.55	12.75	13.53	12.53	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Markham	Wind Gust Below 60 km/h	359.05	358.92	358.92	358.66	358.81	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Markham	Wind Gust Between 61 and 80 km/h	2.14	2.27	2.27	2.52	2.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 81 and 100 km/h	0.05	0.06	0.06	0.07	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Markham	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Markham	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Markham	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Markham	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Richmond Hill	Tmax above 32C	11.27	27.50	48.60	69.47	46.62	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Richmond Hill	Tmax above 40C	0.01	0.25	1.70	5.33	2.16	d/yr	1	2	2	4	2	8	4	2	8	5	2	10	4	2	8
Richmond Hill	Precip above 50mm	1.03	1.10	1.20	1.27	1.18	d/yr	4	3	12	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Precip above 20mm	9.80	11.00	11.45	12.60	11.60	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Richmond Hill	Wind Gust Below 60 km/h	359.05	358.92	358.92	358.66	358.81	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 61 and 80 km/h	2.14	2.27	2.27	2.52	2.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 81 and 100 km/h	0.05	0.06	0.06	0.07	0.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Richmond Hill	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Richmond Hill	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Richmond Hill	Tornado	0.01	0.02	0.03	0.05	0.03	events/yr	1	3	3	2	3	6	2	3	6	2	3	6	2	3	6
Richmond Hill	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Richmond Hill	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Vaughan	Tmax above 32C	11.28	27.89	49.29	70.26	47.22	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Tmax above 40C	0.01	0.24	1.51	5.42	2.11	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Vaughan	Precip above 50mm	1.06	1.20	1.30	1.33	1.27	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Precip above 20mm	9.89	11.20	11.90	13.07	11.96	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Below 60 km/h	359.05	358.92	358.92	358.66	358.81	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Vaughan	Wind Gust Between 61 and 80 km/h	12.61	13.02	13.02	13.79	13.37	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 81 and 100 km/h	1.44	1.53	1.53	1.69	1.60	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Vaughan	Wind Gust Between 101 and 120 km/h	0.10	0.11	0.11	0.12	0.11	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Vaughan	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Vaughan	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Vaughan	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Brampton	Tmax above 32C	11.01	28.01	49.89	71.03	47.70	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Tmax above 40C	0.01	0.21	1.46	5.21	2.03	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Brampton	Precip above 50mm	1.07	1.25	1.45	1.47	1.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Precip above 20mm	10.39	11.40	12.65	13.33	12.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Brampton	Wind Gust Below 60 km/h	347.10	346.59	346.59	345.64	346.16	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Brampton	Wind Gust Between 61 and 80 km/h	12.61	13.02	13.02	13.79	13.37	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Brampton	Wind Gust Between 81 and 100 km/h	1.44	1.53	1.53	1.69	1.60	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Brampton	Wind Gust Between 101 and 120 km/h	0.10	0.11	0.11	0.12	0.11	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Brampton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.01	0.01	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Brampton	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Brampton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	4	4	4	4	16	4	4	16	4	4	16	4	4	16
Brampton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Mississauga	Tmax above 32C	12.19	28.76	49.62	70.51	47.73	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Tmax above 40C	0.01	0.28	1.84	5.70	2.33	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Mississauga	Precip above 50mm	1.15	1.25	1.55	1.60	1.45	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Precip above 20mm	10.31	11.35	12.70	13.33	12.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Below 60 km/h	347.10	346.59	346.59	345.64	346.16	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Mississauga	Wind Gust Between 61 and 80 km/h	12.61	13.02	13.02	13.79	13.37	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Mississauga	Wind Gust Between 81 and 100 km/h	1.44	1.53	1.53	1.69	1.60	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Between 101 and 120 km/h	0.10	0.11	0.11	0.12	0.11	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Mississauga	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.01	0.01	d/yr	2	4	8	3	4	12	3	4	12	3	4	12	3	4	12
Mississauga	Tornado	0.19	0.26	0.43	0.70	0.37	events/yr	1	4	4	2	4	8	2	4	8	2	4	8	2	4	8
Mississauga	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Mississauga	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
Guelph-Rockwood	Tmax above 32C	7.29	22.42	43.92	65.04	41.86	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Tmax above 40C	0.00	0.12	0.52	3.51	1.19	d/yr	1	3	3	3	3	9	4	3	12	5	3	15	4	3	12
Guelph-Rockwood	Precip above 50mm	1.01	1.05	1.40	1.40	1.27	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Precip above 20mm	10.35	11.70	12.70	13.67	12.60	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Below 60 km/h	360.51	360.46	360.46	360.36	360.42	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Guelph-Rockwood	Wind Gust Between 61 and 80 km/h	8.90	9.23	9.23	9.86	9.52	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Guelph-Rockwood	Wind Gust Between 81 and 100 km/h	0.78	0.83	0.83	0.93	0.88	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Wind Gust Between 101 and 120 km/h	0.04	0.04	0.04	0.05	0.05	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Tornado	0.14	0.18	0.31	0.50	0.26	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Guelph-Rockwood	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Guelph-Rockwood	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Tmax above 32C	11.70	29.54	51.40	72.42	49.18	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Tmax above 40C	0.01	0.26	1.15	5.13	1.91	d/yr	1	2	2	4	2	8	4	2	8	5	2	10	4	2	8
Hamilton	Precip above 50mm	1.06	1.15	1.45	1.47	1.35	d/yr	4	4	16	5	4	20	5	4	20	5	4	20	5	4	20
Hamilton	Precip above 20mm	10.89	12.20	13.70	14.20	13.29	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Hamilton	Wind Gust Between 61 and 80 km/h	12.68	13.11	13.11	13.91	13.48	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Hamilton	Wind Gust Between 81 and 100 km/h	1.33	1.42	1.42	1.58	1.49	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Hamilton	Wind Gust Between 101 and 120 km/h	0.08	0.09	0.09	0.10	0.09	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Hamilton	Tornado	0.29	0.39	0.65	1.05	0.55	events/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Hamilton	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	5	5	4	5	20	4	5	20	4	5	20	4	5	20
Hamilton	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	4	16	4	4	16	4	4	16	4	4	16	4	4	16
St. Catharines	Tmax above 32C	10.35	28.74	51.56	72.76	49.04	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Tmax above 40C	0.00	0.08	0.66	4.14	1.40	d/yr	1	2	2	3	2	6	4	2	8	5	2	10	4	2	8
St. Catharines	Precip above 50mm	1.00	1.05	1.25	1.13	1.15	d/yr	4	2	8	5	2	10	5	2	10	5	2	10	5	2	10
St. Catharines	Precip above 20mm	10.44	11.55	12.95	13.27	12.53	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Below 60 km/h	356.93	356.73	356.73	356.35	356.56	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
St. Catharines	Wind Gust Between 61 and 80 km/h	15.70	16.20	16.20	17.11	16.74	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 81 and 100 km/h	1.89	2.00	2.00	2.21	2.11	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
St. Catharines	Wind Gust Between 101 and 120 km/h	0.13	0.14	0.14	0.16	0.15	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Wind Gust Over 121 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Tornado	0.10	0.13	0.22	0.35	0.18	events/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
St. Catharines	Derecho	0.05	0.25	0.25	0.25	0.25	events/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
St. Catharines	Ice Storms	0.34	0.34	0.34	0.34	0.34	events/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12

Appendix D
Risk Profile – Grid-Cell Level

Tables D-1 to Table D-3 present the results of the climate analysis as detailed in Section 2, at a grid-cell level. Column 3 of the tables present the frequency of occurrences of climate parameters, as described in Section 2.4. The results of the risk assessment for each time horizon i.e., Baseline (1950-2020), Near Term (2021-2040), Mid-Century (2041-2060), Long Term (2061-2075) and Study Period (2021-2075) are provided in Columns 4 to 8 respectively. The Likelihood score (L) is calculated based on the standardized probability scoring, as described in Section 2.5. The severity of the climate event is estimated based on the outage analysis, as described in Section 3. The severity score (S) is calculated based on the standardized severity score described in Section 4. The risk score was calculated based on the risk methodology described in Section 4.

Table D-1: Risk Profile Grid-Cell Level, under SSP1-2.6 (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 13 - Hamilton	Tmax above 32C	11.37	26.45	33.85	36.80	31.96	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 13 - Hamilton	Tmax above 40C	-	0.05	0.40	0.33	0.25	d/yr	1	1	1	1	1	1	4	1	4	4	1	4	4	1	4
Cell 13 - Hamilton	Precip above 50mm	0.80	0.90	1.05	1.13	1.02	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 13 - Hamilton	Precip above 20mm	10.28	11.60	12.30	12.33	12.05	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Below 60 km/h	347.15	346.89	346.81	346.72	346.80	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Between 61 and 80 km/h	0.08	0.08	0.08	0.08	0.08	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 81 and 100 km/h	12.68	12.90	12.97	13.04	12.97	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 101 and 120 km/h	1.33	1.37	1.39	1.40	1.39	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 14 - Hamilton	Tmax above 32C	12.11	28.05	34.65	37.87	33.13	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Tmax above 40C	-	0.15	0.40	0.27	0.27	d/yr	1	1	1	3	1	3	4	1	4	4	1	4	4	1	4
Cell 14 - Hamilton	Precip above 50mm	0.87	0.95	1.05	1.20	1.05	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
Cell 14 - Hamilton	Precip above 20mm	9.97	11.40	12.00	11.93	11.76	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 15 - Hamilton	Tmax above 32C	12.17	27.90	34.60	37.67	33.00	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 15 - Hamilton	Tmax above 40C	-	0.10	0.40	0.27	0.25	d/yr	1	1	1	2	1	2	4	1	4	4	1	4	4	1	4
Cell 15 - Hamilton	Precip above 50mm	0.92	1.00	1.05	1.13	1.05	d/yr	4	3	12	5	3	15	4	3	12	5	3	15	4	3	12
Cell 15 - Hamilton	Precip above 20mm	9.89	11.15	11.80	11.73	11.55	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 15 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 23 - Hamilton	Tmax above 32C	12.56	28.70	35.50	39.07	34.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Tmax above 40C	-	0.20	0.50	0.33	0.35	d/yr	1	3	3	3	3	9	4	3	12	4	3	12	4	3	12
Cell 23 - Hamilton	Precip above 50mm	0.90	1.05	1.05	1.20	1.09	d/yr	4			5			4			5			4		
Cell 23 - Hamilton	Precip above 20mm	10.34	11.60	12.30	12.13	12.00	d/yr	5			5			5			5			5		
Cell 23 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Near Term (2021-2040)			Mid-Century (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 23 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Cell 24 - Hamilton	Tmax above 32C	15.08	31.70	38.50	42.13	37.02	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 24 - Hamilton	Tmax above 40C	-	0.30	0.75	0.80	0.60	d/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Cell 24 - Hamilton	Precip above 50mm	0.96	1.05	1.15	1.20	1.13	d/yr	4	3	12	5	3	15	4	3	12	5	3	15	4	3	12
Cell 24 - Hamilton	Precip above 20mm	10.21	11.35	12.25	11.87	11.82	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 24 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Cell 52 - Brampton	Tmax above 32C	11.25	26.25	33.45	36.13	31.56	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 52 - Brampton	Tmax above 40C	-	0.10	0.35	0.20	0.22	d/yr	1	3	3	2	3	6	4	3	12	3	3	9	3	3	9
Cell 52 - Brampton	Precip above 50mm	1.04	1.10	1.20	1.20	1.16	d/yr	4	1	4	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Precip above 20mm	10.10	11.35	12.00	11.53	11.64	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Below 60 km/h	347.10	346.85	346.76	346.68	346.76	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 61 and 80 km/h	0.10	0.10	0.10	0.11	0.10	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 81 and 100 km/h	12.61	12.81	12.88	12.95	12.88	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Between 101 and 120 km/h	1.44	1.49	1.50	1.51	1.50	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9
Cell 69 - Markham	Tmax above 32C	11.15	25.75	32.55	34.67	30.65	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Tmax above 40C	-	0.15	0.45	0.33	0.31	d/yr	1	3	3	3	3	9	4	3	12	4	3	12	4	3	12
Cell 69 - Markham	Precip above 50mm	1.00	1.05	1.20	1.00	1.09	d/yr	4	3	12	5	3	15	4	3	12	4	3	12	4	3	12
Cell 69 - Markham	Precip above 20mm	9.80	11.30	11.30	11.07	11.24	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Below 60 km/h	359.05	358.99	358.97	358.94	358.97	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 69 - Markham	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 81 and 100 km/h	2.14	2.21	2.23	2.25	2.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 101 and 120 km/h	0.05	0.05	0.06	0.06	0.06	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Cell 69 - Markham	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	3	4	12	3	4	12	3	4	12	3	4	12	3	4	12
Cell 7 - St. Catharines	Tmax above 32C	9.37	25.60	33.10	36.73	31.36	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 7 - St. Catharines	Tmax above 40C	-	-	0.05	-	0.02	d/yr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cell 7 - St. Catharines	Precip above 50mm	0.87	0.95	0.95	1.07	0.98	d/yr	4	3	12	4	3	12	4	3	12	5	3	15	4	3	12
Cell 7 - St. Catharines	Precip above 20mm	10.17	11.10	11.90	12.00	11.64	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Below 60 km/h	343.53	343.22	343.12	343.01	342.97	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 61 and 80 km/h	0.13	0.13	0.14	0.14	0.14	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 81 and 100 km/h	15.61	15.95	16.03	16.11	16.15	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Between 101 and 120 km/h	1.89	1.94	1.96	1.98	1.98	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Over 121 km/h	0.01	0.01	0.01	0.01	0.01	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9

Table D-2: Risk Profile Grid-Cell Level, under SSP2-4.5 (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 13 - Hamilton	Tmax above 32C	11.17	27.75	38.05	48.67	37.20	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 13 - Hamilton	Tmax above 40C	-	0.05	0.30	0.93	0.38	d/yr	1	1	1	1	1	1	4	1	4	4	1	4	4	1	4
Cell 13 - Hamilton	Precip above 50mm	0.82	1.00	1.15	1.07	1.07	d/yr	4	3	12	4	3	12	5	3	15	5	3	15	4	3	12
Cell 13 - Hamilton	Precip above 20mm	10.23	12.10	12.60	12.93	12.51	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Below 60 km/h	347.15	346.89	346.72	346.46	346.69	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Between 61 and 80 km/h	0.08	0.08	0.08	0.09	0.08	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 81 and 100 km/h	12.68	12.90	13.04	13.26	13.06	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 101 and 120 km/h	1.33	1.37	1.40	1.44	1.41	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 14 - Hamilton	Tmax above 32C	11.96	29.25	38.85	49.60	38.29	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Tmax above 40C	-	0.05	0.35	1.13	0.45	d/yr	1	1	1	1	1	1	4	1	4	4	1	4	4	1	4
Cell 14 - Hamilton	Precip above 50mm	0.86	1.00	1.15	1.07	1.07	d/yr	4	2	8	4	2	8	5	2	10	5	2	10	4	2	8
Cell 14 - Hamilton	Precip above 20mm	10.01	11.95	12.10	12.73	12.22	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 15 - Hamilton	Tmax above 32C	12.01	29.45	38.80	49.27	38.25	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 15 - Hamilton	Tmax above 40C	-	0.05	0.40	1.07	0.45	d/yr	1	1	1	1	1	1	4	1	4	4	1	4	4	1	4
Cell 15 - Hamilton	Precip above 50mm	0.92	1.00	1.20	1.07	1.09	d/yr	4	3	12	4	3	12	5	3	15	5	3	15	4	3	12
Cell 15 - Hamilton	Precip above 20mm	9.89	11.85	12.20	12.73	12.22	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 15 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 23 - Hamilton	Tmax above 32C	12.42	30.20	39.90	50.93	39.38	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Tmax above 40C	-	0.25	0.50	1.40	0.65	d/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Cell 23 - Hamilton	Precip above 50mm	0.94	1.05	1.20	1.13	1.13	d/yr	4			4			5			5			4		
Cell 23 - Hamilton	Precip above 20mm	10.34	12.15	12.60	12.67	12.45	d/yr	5			5			5			5			5		
Cell 23 - Hamilton	Wind Gust Below 60 km/h	361.23	356.83	356.76	356.66	356.76	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 23 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	4.14	4.21	4.30	4.21	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.26	0.27	0.28	0.27	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 23 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Cell 24 - Hamilton	Tmax above 32C	14.94	33.55	42.10	53.27	42.04	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 24 - Hamilton	Tmax above 40C	-	0.30	0.90	1.87	0.95	d/yr	1	3	3	4	3	12	4	3	12	4	3	12	4	3	12
Cell 24 - Hamilton	Precip above 50mm	0.97	1.10	1.20	1.27	1.18	d/yr	4	3	12	4	3	12	5	3	15	5	3	15	4	3	12
Cell 24 - Hamilton	Precip above 20mm	10.21	11.95	12.35	12.60	12.27	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Below 60 km/h	361.23	356.83	356.76	356.66	356.76	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 24 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	4.14	4.21	4.30	4.21	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.26	0.27	0.28	0.27	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Cell 52 - Brampton	Tmax above 32C	11.03	27.35	37.35	47.73	36.55	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 52 - Brampton	Tmax above 40C	-	0.05	0.25	1.33	0.47	d/yr	1	3	3	1	3	3	3	3	9	4	3	12	4	3	12
Cell 52 - Brampton	Precip above 50mm	1.03	1.10	1.10	1.47	1.20	d/yr	4	1	4	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Precip above 20mm	10.06	11.40	11.65	12.07	11.67	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Below 60 km/h	347.10	343.22	343.01	342.70	342.84	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 61 and 80 km/h	0.10	0.13	0.14	0.14	0.14	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 81 and 100 km/h	12.61	15.95	16.11	16.36	16.26	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Between 101 and 120 km/h	1.44	1.94	1.98	2.03	2.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Over 121 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9
Cell 69 - Markham	Tmax above 32C	10.90	26.55	36.50	46.13	35.51	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Tmax above 40C	-	0.10	0.30	1.40	0.53	d/yr	1	3	3	2	3	6	4	3	12	4	3	12	4	3	12
Cell 69 - Markham	Precip above 50mm	1.00	1.05	1.20	1.07	1.11	d/yr	4	3	12	4	3	12	5	3	15	4	3	12	4	3	12
Cell 69 - Markham	Precip above 20mm	9.73	10.80	11.15	12.00	11.25	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Below 60 km/h	359.05	343.22	343.01	342.70	342.84	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 69 - Markham	Wind Gust Between 61 and 80 km/h	0.00	0.13	0.14	0.14	0.14	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 81 and 100 km/h	2.14	15.95	16.11	16.36	16.26	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 101 and 120 km/h	0.05	1.94	1.98	2.03	2.00	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Cell 69 - Markham	Wind Gust Over 121 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	3	4	12	3	4	12	3	4	12	3	4	12	3	4	12
Cell 7 - St. Catharines	Tmax above 32C	9.17	26.95	37.70	49.20	36.93	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 7 - St. Catharines	Tmax above 40C	-	-	-	0.07	0.02	d/yr	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1
Cell 7 - St. Catharines	Precip above 50mm	0.89	1.05	1.00	1.07	1.04	d/yr	4	3	12	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Precip above 20mm	10.14	11.70	12.05	12.27	11.98	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Below 60 km/h	343.53	351.34	351.21	351.01	351.18	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 61 and 80 km/h	0.13	0.04	0.04	0.04	0.04	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 81 and 100 km/h	15.61	9.06	9.18	9.34	9.20	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Between 101 and 120 km/h	1.89	0.81	0.82	0.85	0.83	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040)			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 7 - St. Catharines	Wind Gust Over 121 km/h	0.01	0.00	0.00	0.00	0.00	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9

Table D-3: Risk Profile Grid-Cell Level, under SSP5-8.5 (L= Likelihood, S = Severity, R = Risk Rating)

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040))			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 13 - Hamilton	Tmax above 32C	11.61	29.30	50.90	72.07	48.82	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 13 - Hamilton	Tmax above 40C	0.01	0.25	1.05	4.73	1.76	d/yr	1	1	1	3	1	3	4	1	4	5	1	5	4	1	4
Cell 13 - Hamilton	Precip above 50mm	0.82	0.95	1.15	1.13	1.07	d/yr	4	3	12	4	3	12	5	3	15	5	3	15	4	3	12
Cell 13 - Hamilton	Precip above 20mm	10.23	11.70	12.70	13.53	12.56	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Below 60 km/h	347.15	346.63	346.63	345.65	346.19	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 13 - Hamilton	Wind Gust Between 61 and 80 km/h	0.08	0.09	0.09	0.10	0.09	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 81 and 100 km/h	12.68	13.11	13.11	13.91	13.48	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Between 101 and 120 km/h	1.33	1.42	1.42	1.58	1.49	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 13 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 14 - Hamilton	Tmax above 32C	12.52	30.70	51.55	72.33	49.64	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Tmax above 40C	0.01	0.25	1.30	5.27	2.00	d/yr	1	1	1	3	1	3	4	1	4	5	1	5	4	1	4
Cell 14 - Hamilton	Precip above 50mm	0.87	0.95	1.05	1.07	1.02	d/yr	4	2	8	4	2	8	4	2	8	5	2	10	4	2	8
Cell 14 - Hamilton	Precip above 20mm	9.97	11.30	12.40	13.27	12.24	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 14 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 14 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 15 - Hamilton	Tmax above 32C	12.54	30.60	51.15	71.87	49.33	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 15 - Hamilton	Tmax above 40C	0.01	0.25	1.30	5.27	2.00	d/yr	1	1	1	3	1	3	4	1	4	5	1	5	4	1	4
Cell 15 - Hamilton	Precip above 50mm	0.92	0.95	1.10	1.07	1.04	d/yr	4	3	12	4	3	12	4	3	12	5	3	15	4	3	12
Cell 15 - Hamilton	Precip above 20mm	9.87	11.20	12.15	13.07	12.05	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 15 - Hamilton	Wind Gust Below 60 km/h	361.23	361.23	361.23	361.23	361.23	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	0.02	0.02	0.02	0.02	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 15 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Cell 23 - Hamilton	Tmax above 32C	12.96	31.20	53.50	74.20	51.04	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Tmax above 40C	0.01	0.30	1.55	6.00	2.31	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Cell 23 - Hamilton	Precip above 50mm	0.94	1.00	1.30	1.07	1.13	d/yr	4			4			5			5			4		
Cell 23 - Hamilton	Precip above 20mm	10.38	11.65	12.70	13.53	12.55	d/yr	5			5			5			5			5		
Cell 23 - Hamilton	Wind Gust Below 60 km/h	361.23	356.73	356.73	356.35	356.56	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 23 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	4.24	4.24	4.58	4.39	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.27	0.27	0.31	0.29	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 23 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	4	4	1	4	4	1	4	4	1	4	4	1	4	4
Cell 24 - Hamilton	Tmax above 32C	15.42	34.00	55.05	75.87	53.07	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 24 - Hamilton	Tmax above 40C	0.01	0.50	2.15	7.40	2.98	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12

1	2	3						4			5			6			7			8		
Location	Climate Change Variable	Frequency (events per year)						Baseline (1950-2020)			Short Term (2021-2040))			Medium Term (2041-2060)			Long Term (2061-2075)			Study Period (2021-2075)		
		Baseline (1950-2020)	Short Term (2021-2040)	Medium Term (2041-2060)	Long Term (2061-2075)	Study Period (2021-2075)	Units	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Cell 24 - Hamilton	Precip above 50mm	0.99	1.05	1.40	1.20	1.22	d/yr	4	3	12	4	3	12	5	3	15	5	3	15	4	3	12
Cell 24 - Hamilton	Precip above 20mm	10.23	11.30	12.65	13.27	12.33	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Below 60 km/h	361.23	356.73	356.73	356.35	356.56	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 61 and 80 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	4	3	12	4	3	12	4	3	12	4	3	12	4	3	12
Cell 24 - Hamilton	Wind Gust Between 81 and 100 km/h	0.02	4.24	4.24	4.58	4.39	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Between 101 and 120 km/h	0.00	0.27	0.27	0.31	0.29	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 24 - Hamilton	Wind Gust Over 121 km/h	0.00	0.00	0.00	0.00	0.00	d/yr	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Cell 52 - Brampton	Tmax above 32C	11.48	28.55	50.55	71.60	48.29	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 52 - Brampton	Tmax above 40C	0.01	0.25	1.55	5.27	2.09	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Cell 52 - Brampton	Precip above 50mm	1.01	1.20	1.40	1.33	1.31	d/yr	4	1	4	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Precip above 20mm	10.08	11.15	12.30	13.07	12.09	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Below 60 km/h	347.10	342.91	342.91	341.76	342.24	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 61 and 80 km/h	0.10	0.14	0.14	0.16	0.15	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 52 - Brampton	Wind Gust Between 81 and 100 km/h	12.61	16.20	16.20	17.11	16.74	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Between 101 and 120 km/h	1.44	2.00	2.00	2.21	2.11	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 52 - Brampton	Wind Gust Over 121 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9
Cell 69 - Markham	Tmax above 32C	11.41	27.80	48.75	69.87	46.89	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Tmax above 40C	0.01	0.30	1.75	5.40	2.22	d/yr	1	3	3	4	3	12	4	3	12	5	3	15	4	3	12
Cell 69 - Markham	Precip above 50mm	1.00	1.15	1.20	1.33	1.22	d/yr	4	3	12	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Precip above 20mm	9.85	10.80	11.70	12.67	11.64	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Below 60 km/h	359.05	342.91	342.91	341.76	342.24	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 69 - Markham	Wind Gust Between 61 and 80 km/h	0.00	0.14	0.14	0.16	0.15	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 81 and 100 km/h	2.14	16.20	16.20	17.11	16.74	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 69 - Markham	Wind Gust Between 101 and 120 km/h	0.05	2.00	2.00	2.21	2.11	d/yr	5	4	20	5	4	20	5	4	20	5	4	20	5	4	20
Cell 69 - Markham	Wind Gust Over 121 km/h	0.00	0.01	0.01	0.01	0.01	d/yr	3	4	12	3	4	12	3	4	12	3	4	12	3	4	12
Cell 7 - St. Catharines	Tmax above 32C	9.65	28.00	52.35	73.47	49.25	d/yr	5	1	5	5	1	5	5	1	5	5	1	5	5	1	5
Cell 7 - St. Catharines	Tmax above 40C	-	-	0.45	3.80	1.20	d/yr	1	1	1	1	1	1	4	1	4	4	1	4	4	1	4
Cell 7 - St. Catharines	Precip above 50mm	0.89	1.00	1.00	1.00	1.00	d/yr	4	3	12	5	3	15	4	3	12	5	3	15	4	3	12
Cell 7 - St. Catharines	Precip above 20mm	10.13	11.35	12.60	12.87	12.22	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Below 60 km/h	343.53	351.14	351.14	350.41	350.81	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 61 and 80 km/h	0.13	0.04	0.04	0.05	0.05	d/yr	5	2	10	5	2	10	5	2	10	5	2	10	5	2	10
Cell 7 - St. Catharines	Wind Gust Between 81 and 100 km/h	15.61	9.23	9.23	9.86	9.52	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Between 101 and 120 km/h	1.89	0.83	0.83	0.93	0.88	d/yr	5	3	15	5	3	15	5	3	15	5	3	15	5	3	15
Cell 7 - St. Catharines	Wind Gust Over 121 km/h	0.01	0.00	0.00	0.00	0.00	d/yr	3	3	9	3	3	9	3	3	9	3	3	9	3	3	9