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» PIEVC HIGH LEVEL SCREENING GUIDE «

A guide to completing screening level climate change risk assessments using the PIEVC Process

Published by the PIEVC Global Partnership:

Institute for Catastrophic Loss Reduction
Building resilient communities

CLIMATE RISK INSTITUTE

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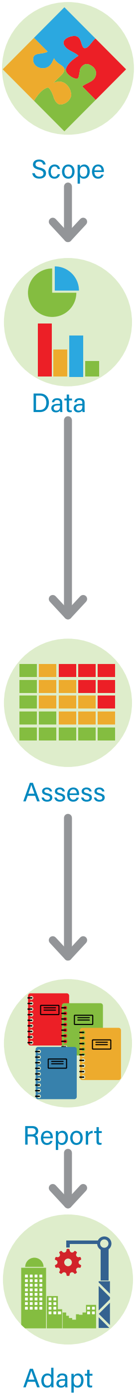

Scope
Data
Assess
Report
Adapt

Key Terms

Vocabulary	Definition
Adaptation	Process of adjustment to actual or expected climate and its effects.
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Climate Hazard	Specific impactful event as related to the broader climate parameter category.
Climate Hazard Indicator	Specific climate values (TMax > 35C; Precip > 100mm; Freezing Rain > 30 mm, etc.) that are defined by their ability to impact an infrastructure system or component (i.e., exceed a threshold).
Climate Parameter	Broader categories of measurable climate conditions in relation to which specific climate hazards or indicators can be defined. Climate parameters include temperature, precipitation, sea-level rise, wind, etc.
Consequence	Outcome of an event affecting objectives.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social or cultural assets in places and settings that could be affected.
Element	A distinct part of an asset or system. Could include physical, planning or human resources.
Likelihood	Chance of something occurring; within the context of climate risk assessment, the chance of a defined climate hazard over a given time horizon.
Portfolio	A collection of assets or policies that are characterized by different risks.
Probability	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty.
Residual Risk	Risk remaining after risk treatment.
Resilience	The capacity to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure.
Risk	Effect of uncertainty on objectives. This guide applies the following formula as a measure of risk. Risk = Exposure x Likelihood x Consequence.
Risk Appetite	Amount and type of risk that an organization is willing to pursue or retain.
Risk Tolerance	Readiness to bear the risk after risk treatment.
Risk Treatment	Process to modify risk.
Threshold	Point beyond which a system, because of physical damage or failure, is deemed to be no longer effective or safe: Economically; Socially; Technologically; Physically; or Environmentally. Also known as tipping point.
Vulnerability	Propensity or predisposition to be adversely affected.

PIEVC Protocol terms used in this Guide are updated from the PIEVC Protocol to align with international risk management standards ISO 31000 and ISO 14090, and other risk assessment processes. Specific updates are noted in call-out boxes throughout the Guide.

A Detailed Glossary is provided in the Appendices.

Introduction

Climate Risk Assessments of Infrastructure

Climate risk assessments are a crucial component to guide, design and operate infrastructure and systems that are resilient to the effects of extreme weather and our changing climate. Climate risk assessment is a process of identifying how assets respond to and recover from the effects of a variety of hazards attributed to climate impacts. Many governments and organizations are using or requiring climate risk assessment to inform adaptation action.

Applications of the PIEVC HLSG Process

This PIEVC High Level Screening Guide (HLSG) is based on standard climate risk assessment methods. It may be used to conduct climate risk and resiliency assessments to support a range of applications, including:

- Infrastructure Canada's Climate Lens (resilience assessment component).
- Provincial and municipal climate lens assessment requirements.
- Assessments to support applications of the First Nations Infrastructure Resiliency Toolkit.
- Asset management, capital and master planning.
- Infrastructure operations and management evaluation and review.
- Asset portfolio assessment and evaluation.
- Concept and preliminary engineering design.
- Green and natural infrastructure assessments.
- Preliminary reporting on climate risk as part of Carbon Disclosure Project or other financial requirements.
- Informing Emergency Management and Business Continuity Management practices.
- Applications requiring standard risk assessment methodologies compliant with ISO 31000 and ISO 14090.

The Canadian Council of Ministers of the Environment (CCME) includes the PIEVC Process in its Guidance on Good Practices in Climate Change Risk Assessment.

The PIEVC Program

The PIEVC Program is owned and operated through a partnership consisting of the Institute for Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The PIEVC HLSG process is used internationally, to support many of the same types of application as indicated for Canadian practitioners. Additional resources and information on how to access to the **PIEVC Protocol** and this P**IEVC HLSG** can be found at **www.pievc.ca**.

The PIEVC Process

In 2005, Engineers Canada established a national committee called the **Public Infrastructure Engineering Vulnerability Committee (PIEVC)** to oversee development and delivery of a national Protocol for the evaluation of risks related to the impacts of climate change on physical infrastructure in Canada. The **PIEVC Protocol** has now been used in hundreds of assessments of various types of individual infrastructure, larger infrastructure systems, and infrastructure portfolios in Canada and internationally. The **PIEVC Protocol** describes a step-by-step methodology of risk assessment and optional engineering analysis for evaluating the impact of changing climate on infrastructure. The observations, conclusions and recommendations derived from the application of the PIEVC Protocol provide a framework to support effective decision-making.

As use of the **PIEVC Protocol** evolved, stakeholders identified the need for a more streamlined and less complex version of the methodology. The **PIEVC High Level Screening Guide (PIEVC HLSG)**, answers this need.

The **PIEVC HLSG** is designed to help provide a high-level assessment of the potential risks posed by climate change to infrastructure and related elements. Generally, the distinction between the **PIEVC HLSG** and the **PIEVC Protocol** is the level of detail pursued at each step. The **PIEVC HLSG** process is written such that information can be obtained from readily available sources and based on a high degree of professional and engineering judgement. The **PIEVC HLSG** process may also be the initial screening step before other processes or further detailed assessment. It provides a simplified level of assessment for evaluating climate risk. Compared to most PIEVC Protocol assessments, **PIEVC HLSG** assessments:

- Use a smaller number of elements to define an infrastructure system or portfolio.
- Use climate analyses and projections from readily available sources.
- Require considerably less effort and time.
- Enable the grouping of assets by class or "like" conditions for more rapid risk screening.

The **PIEVC HLSG** process, although simplified, requires professional judgement in engineering and climate science. **A professional engineer, climate specialist and subject matter experts specific to the type of infrastructure being assessed should be engaged in the assessment.**

The PIEVC High Level Screening Guide

The **PIEVC HLSG** process is an approach for undertaking vulnerability, risk, and resilience assessments. It is flexible enough to be applied to full assets or systems, to a single element of infrastructure, or to an entire portfolio of numerous assets. **PIEVC HLSG** assessments result in the characterization and ranking of climate risk scenarios and the identification of those scenarios of highest priority for adaptation planning or more comprehensive analysis.

The **PIEVC HLSG** process requires an understanding of the elements under assessment; life of the elements in terms of timescale of the assessment; risk assessment principles; climate science, climate hazards and climate change principles; the consequence of the interaction of elements under assessment and climate, and; options for developing risk actions and adaptation strategies, which may include deeper climate risk assessments.

Which PIEVC Process should I use?

Desired Assessment Outcome	Suggested PIEVC Assessment Process
Infrastructure Canada's Climate Lens (Resilience Assessment) or other form of climate lens at the provincial or municipal level	PIEVC HLSG
Asset Management, Capital and Master Planning	PIEVC HLSG
Inform Conceptual/Pre-Design Process	PIEVC HLSG/ PIEVC Protocol
Build awareness, training and capacity	PIEVC HLSG
Portfolio Applications	PIEVC HLSG / PIEVC Protocol
Green Infrastructure assessments	PIEVC HLSG / PIEVC Protocol
Applications requiring standard risk assessment methodologies compliant with ISO 31000 and ISO 14090	PIEVC HLSG / PIEVC Protocol
Inform Detail Design Process (new, existing)	PIEVC HLSG with Engineering Analysis / PIEVC Protocol
Detailed Risk Assessment of Public Infrastructure (new, existing)	PIEVC HLSG with engineering Analysis / PIEVC Protocol

Tip - Explore using the PIEVC HLSG first where both the HLSG and PIEVC Protocol are recommended. If more detail, scrutiny, or engineering judgement is required, you may choose to instead use the PIEVC Protocol. Recommendations to proceed with the PIEVC Protocol may be a finding of the completion of the HLSG process.

Assessment Team

Engagement with subject matter experts and stakeholders with local knowledge is a constant theme throughout the **PIEVC HLSG** Process. Each step of the assessment process requires a different mix of skills and personnel depending on locations and asset categories specific to single asset(s) or Portfolios. While the level of engagement is dictated by the objectives of each assessment, this **PIEVC HLSG** Process offers a suggested listing of possible assessment team participants. This is outlined within each section and also on the **Application Map** that serves as the roadmap to guide users through the guide.

Examples of **Team Resources** may include (*required):

- **Risk Assessment:** The risk assessment specialist(s)* have in-depth knowledge of the fundamentals of risk and the PIEVC Process. They have strong skills in facilitation and communication that strengthen the knowledge and expertise of other team resources and guide the process.
- Climate: The climate specialist(s)* have a strong understanding of climate that is relevant to the local context. They can interpret climate data and communicate uncertainty effectively with other team resources.
- **Planning:** Individuals or groups with knowledge of community planning, land-use planning, infrastructure planning and other related expertise relevant to the scope of the assessment (like transportation) can provide a broader understanding of multi-stakeholder goals and relevant policy.
- **Technical / Engineering:** Professional Engineer(s)*, technical or engineering subject matter specialist(s) have relevant experience working with the infrastructure or systems being assessed.
- **Natural Environment:** Natural environment subject matter specialists have relevant experience working with and managing natural systems. Expertise needed will vary depending on the assessment scope but can include knowledge about sustainability, hydrology, landscape architecture, ecology, aquatic biology, or forest management.
- **Operation & Maintenance:** Individuals or groups involved in operations and maintenance can provide valuable insight into the system being assessed or similar systems they have worked with previously.
- **Management, Finance:** Individuals or groups involved with financing or managing the assets can assist with encouraging buy-in across the organization and aligning project objectives with the organization's goals and strategy.
- **Legal, Insurance:** Individuals or groups with legal and insurance expertise can provide insight on topics like liability, risk tolerance, the ability to acquire insurance, and relevant policy.
- **People:** Non-organizational stakeholders who rely on the services of the systems or assets being assessed have critical perspectives to contribute related to service disruptions and levels.
- **Indigenous:** Meaningful engagement with Indigenous communities and knowledge holders can improve understanding of climate conditions in the areas and communities being assessed.

Considerations when building your team

1. Not all assessment will require a full team with the resources suggested. In many assessments, several roles may be filled by one or several qualified individuals.
2. Who is interested in participating? Do they have the capacity, time, and expertise?
3. Who will be responsible for project management, establishing timelines, setting up meetings and following up? Will this be one person, or multiple?
4. Are there any existing organizations or groups that you could leverage to champion this process?
5. Do you require any internal/external expertise to analyze or derive climate data or better understand the elements you are assessing?
6. Does the project team represent broad and diverse perspectives from the organization or community that you are working with?
7. How will you solicit team resources? Do you need to establish any formal agreements (like a terms of reference) to participate?
8. Are there other areas of expertise or stakeholders to include?

PIEVC Training

The infrastructure Resilience Professional (IRP) Training Program has been designed to help infrastructure practitioners strengthen the knowledge and competencies they require to advance more climate-resilient approaches for the planning, design, and management of infrastructure. https://climateriskinstitute.ca/irp-page/

Standard of Practice, Limitations and Professional Judgement

In the application of any **PIEVC** process, whether for the **PIEVC HLSG** or PIEVC Protocol, infrastructure risk assessors are expected to carry out their duties according to a recognized standard of practice. Upon completion and reporting of a risk assessment, it is recommended that limitations, assumptions, and appropriate disclaimers be documented in the reporting stage and be approved by a competent user. Users of the **PIEVC HLSG** are encouraged to document uncertainty in all aspects of an assessment, such as those related to limitations or gaps in data used. Likewise, users are encouraged to provide recommendations for next steps and to identify the importance of taking an iterative approach to inform future assessments, as the result of changes to, for example, any of the limitations, climate projections, or risk appetite.

Statement of Assumptions and Limitations A statement of assumptions and limitations explains the boundaries of the assessment in time and in space and offers a sense of the data sensitivities encountered. It provides clarity and guidance on the overall confidence in the work. Examples statements could Include:

- The temporal and spatial scale of global climate models can only simulate patterns on very large scales, resulting in a need for site-specific downscaling studies that were not completed for the assessment.
- The Assessment does not account for cumulative effects of multiple climate events occurring concurrently.
- The Assessment should be updated based on new specific climate projections when they are available.
- The Assessment was based on available information provided.

All participants involved in using the **PIEVC HLSG** assessment should understand what can and cannot be done with assessment results. While it is good practice for risk assessment authors to maintain a good standard of practice, and they may attest to the results of their assessment, in certain contexts it may be required that a Professional Engineer take professional responsibility for the assessment. This may or may not be a requirement of a particular asset owner, regulator, or in cases where engineering assessment is required.

Application of the **PIEVC HLSG** relies on professional judgment. Professional judgment involves arriving at conclusions in accordance with the scope of experience and skills of the practitioner. This is defined by a Professional Engineer's scope of practice. To practice within a specific discipline the engineer must demonstrate a minimum acceptable, not expert, level of training and experience. The individual engineer must only work in areas where they have the skills and training to provide service and are guided in this matter by their code of ethics.

In applying the **PIEVC HLSG**, professional judgment refers to the combined skills, training, expertise and experience of the entire team. Professional judgement is the interpretation and synthesis of data, facts and observations collected by the team and the extrapolation of that analysis to provide a judgment of how the infrastructure may respond to a specific set of conditions. The strength of the process is derived from the combined expertise of the entire team, members contributing in accordance with their own specific scope of practice.

Given the multidisciplinary nature of climate change assessment, it would be exceptional to find the entire scope of skills necessary to establish professional judgment in any one individual. For example, engineers may find themselves limited in their ability to assess climate information, while climate specialists may not be able to comment on the way infrastructure systems respond to specific weather events. However, together they can identify reasonable climate scenarios, relevant to a specific infrastructure component and pass judgment on how that infrastructure would likely respond to that particular stimulus. This is a very different situation than one expert expressing an opinion based on their unique expertise.

Limitations, Documentation and Reporting

Climate change risk assessments face limitations that establish what the work can and cannot indicate to decision-makers. These limitations fall into several consistent categories: Project Scope and Detail; Time Horizons; Data Gaps. Examples of these limitations could include lack of or incomplete data, explicit elements that were not assessed but should or may be in a subsequent step, or uncertainty in climate data and climate projections used. When reporting on the assessment it is important to identify the range of factors considered and how any material data gaps may have been addressed. For example, to compensate for missing or unavailable information teams may apply generalized assumptions, consider information from similar operations at other locations, conduct sensitivity analyses, and a range of other methods. In reporting, it is critical that the team explain any steps they took to address gaps and explain how these approaches may affect the overall confidence in the assessment. Sometimes, there is no way to fill a data gap, and a risk question may remain unaddressed at the end of the assessment. This, in and of itself, represents a risk as there is inherent uncertainty associated with this lack of information. Such cases must be identified, and where appropriate, may form the basis of a recommendation for further action.

Finally, a climate change risk assessment will only assess risk for those elements considered in the scope of work and within a defined geography. Therefore, reporting must be very clear about what the assessment considered, and what was outside of the scope of work. Similarly, reporting should explicitly identify the specific time horizons contemplated in the climate projections. In the formal reporting, the PIEVC HLSG requires an explicit statement of limitations and assumptions.

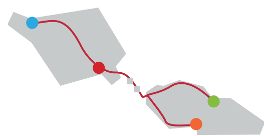
Single Asset and Portfolio Assessments

The **PIEVC HLSG** may be applied to a single infrastructure asset or to sets of multiple assets, called "portfolios." An example of a single asset assessment is the assessment of an individual bridge.

A portfolio is a set of assets owned, operated, or regulated by a single organization. The "single organization" constraint aligns the assessment with the objectives, risk criteria, and risk appetite of one centrally responsible entity, and manager of risk. An example of an asset portfolio assessment is the assessment of numerous bridges, across a transportation network, all at once.

PIEVC HLSG portfolio assessments follow the same general principles used in single asset assessments, though certain steps require additional considerations. Large portfolio assessment may require other processes. A guidance document related to large portfolio assessments is under development as part of the PIEVC Family of Resources.

Examples of Portfolios



We may group asset portfolios into key types:

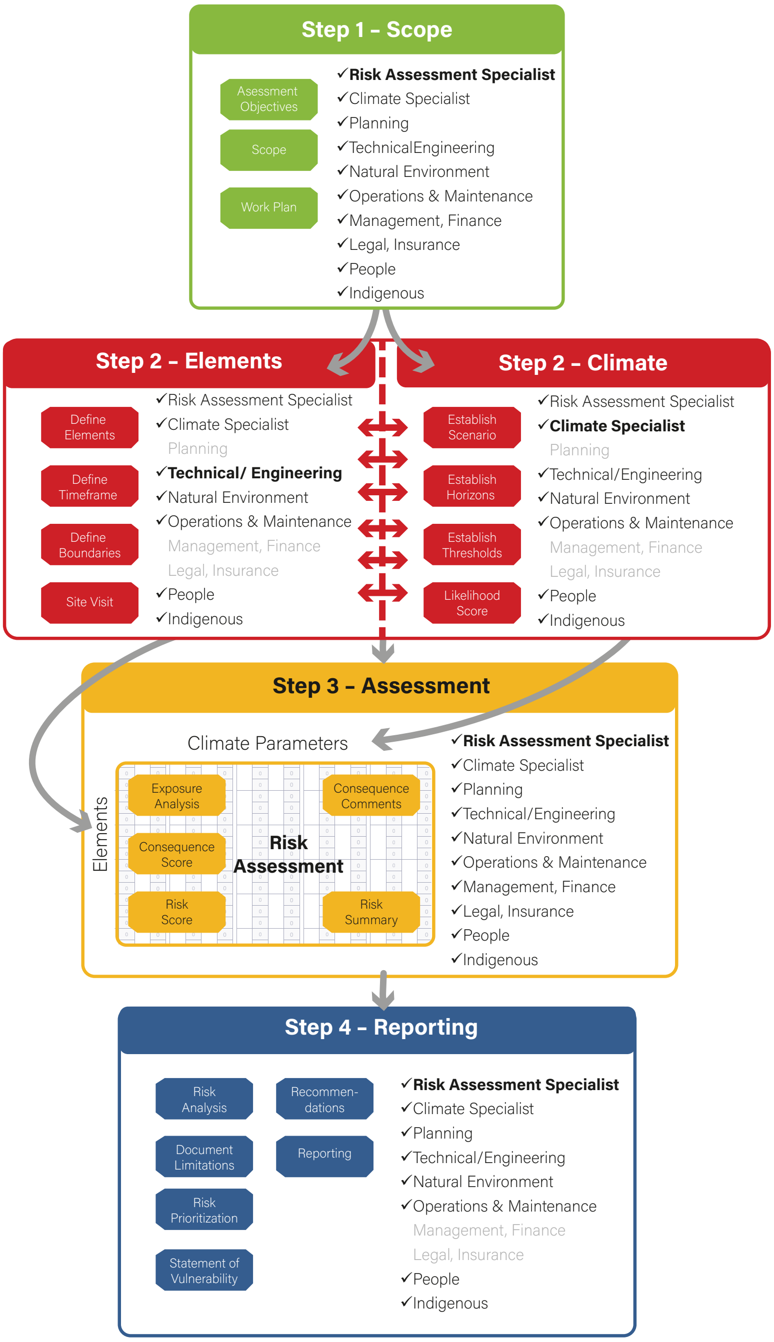
- Similar Assets in Many Locations:
  - Example: All the ports owned by one organization across multiple geographic and climate zones.
- One Location with Multiple Assets
  - Example: An organization with many asset types (roads, waterworks, etc.) in one location.
- One Linear System crossing Multiple Climate Zones
  - Example: A single asset that crosses several climatic zones creating a range of different climate considerations (a highway or pipeline).
- Many Locations with Many Assets
  - Example: A territory assessing the asset portfolios of multiple municipalities under its control.

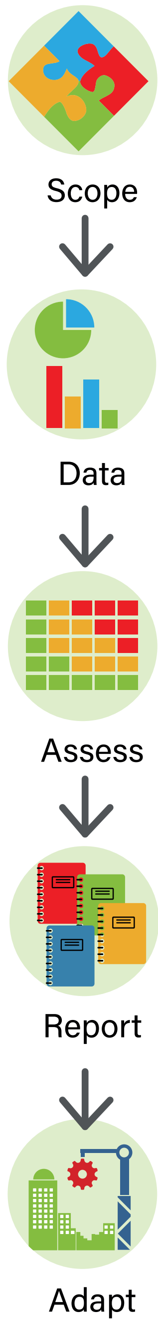
Application Map PIEVC HLSG

The application map shows the steps and considerations to complete an assessment.

Pathways to complete single asset and portfolio assessments are shown on the following page.

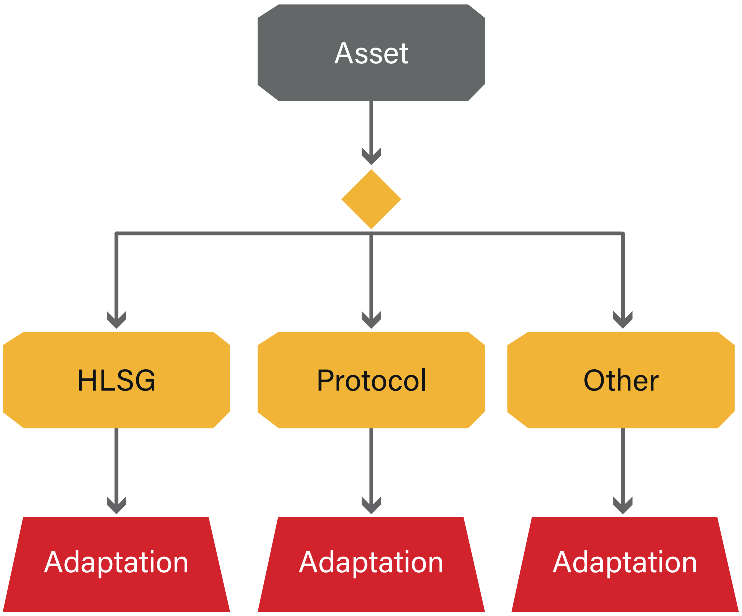
Details related to the steps are Included In the following sections.



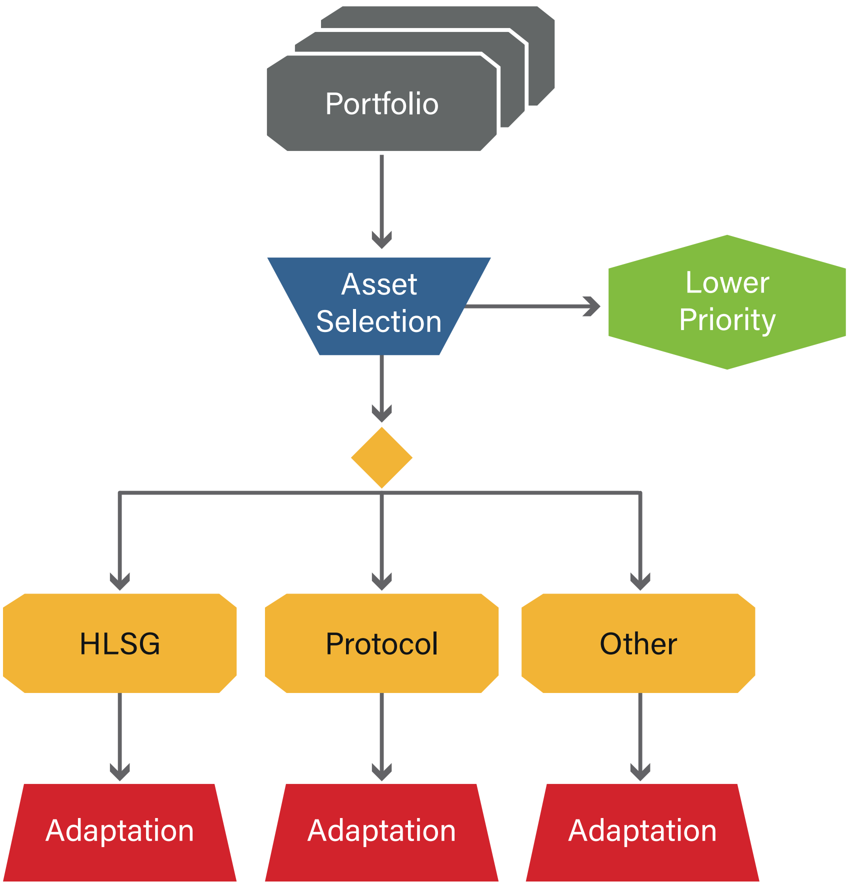


PIEVC HLSG Pathways

Single Asset



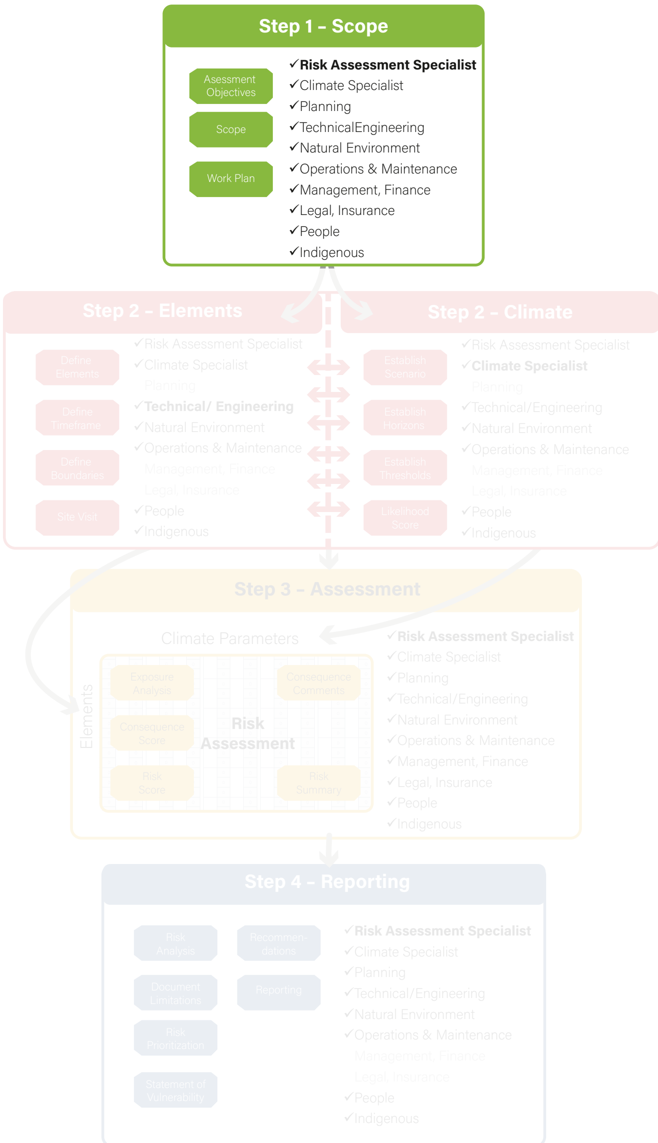
Portfolio



Step 1 – Scope

In this section you will:

- Establish the Scope, Context and Criteria of the Assessment
- Develop a Work Plan and Assessment Team



Objectives

In establishing the context of the **PIEVC HLSG** assessment, the objective should be reviewed and documented. Assessment objectives will differ between assessments and organizations and will relate to understanding and addressing the risk appetite of the organization.

Assessment objectives may include:

- Identifying priority infrastructure and climate change-related risks
- Identifying common risks by infrastructure type, element, or region
- Screening risk to improve management of an asset Portfolio
- Assessing risk as part of a regulatory or funding process
- Ensuring due diligence in managing and governance of assets
- Planning for proposed Infrastructure
- Evaluation of infrastructure operations and maintenance policies and procedures
- Building capacity for climate change risk assessment and adaptation in an organization

The objective of the assessment will dictate its complexity, the time to complete the assessment and the resources and data to complete an assessment. The objective of the assessment will guide the screening of assets to be considered.

Scope

The scope of the assessment will identify key details for the assessment. Assessment scope may include:

- Asset details and boundary conditions
- Level of service standards
- Importance or criticality of assets and sub elements
- Time horizon of the assessment
- Geography or geographies of a Portfolio (considering different climate regions)
- Governance and jurisdictional considerations
- Assessment process selection or screening
- To assist in this process, decision making tools or process may be employed. Examples Include multi factor analysis, SWOT, surveys, etc.

Questions related to Scope:

- Is the element, and its sub elements, relied upon for delivering services across a jurisdiction?
- In the event of a climate impact would damage and/or loss of function to the element cause concern for public safety?
- Has the element, or any of its sub elements, previously been defined as critical via government processes or otherwise?
- Is the element, or any of its sub elements, not necessarily owned or maintained by the risk assessment lead but still considered important by stakeholders and residents (e.g., cultural heritage)?

Portfolio Assessment Asset Selection

In Portfolio Applications an asset selection step may be required to assist in defining the scope of the assessment. Although organizations may want all assets assessed, it may not be feasible or necessary and therefore screening the number of assets considered will reduce the overall complexity and scope of the project.

Considerations for asset selection may include:

- Representative assets (archetype)
- Assets across geographic regions (representative)
- Assets of organizational importance
- Assets of high public importance
- Critical assets
- Age of asset or stage of lifecycle of assessment
- Assets with data availability
- Assets most impacted by past climate events or are in areas known to have climate impacts (current or projected)

Purpose of Assessment

- Future asset planning
- Prioritizing refurbishment
- Regulatory or organizational mandate

Work Plan

An assessment work plan should detail project steps and tasks, timeframes and assessment team members.

Example Work Plan

Based on a simple single asset assessment:

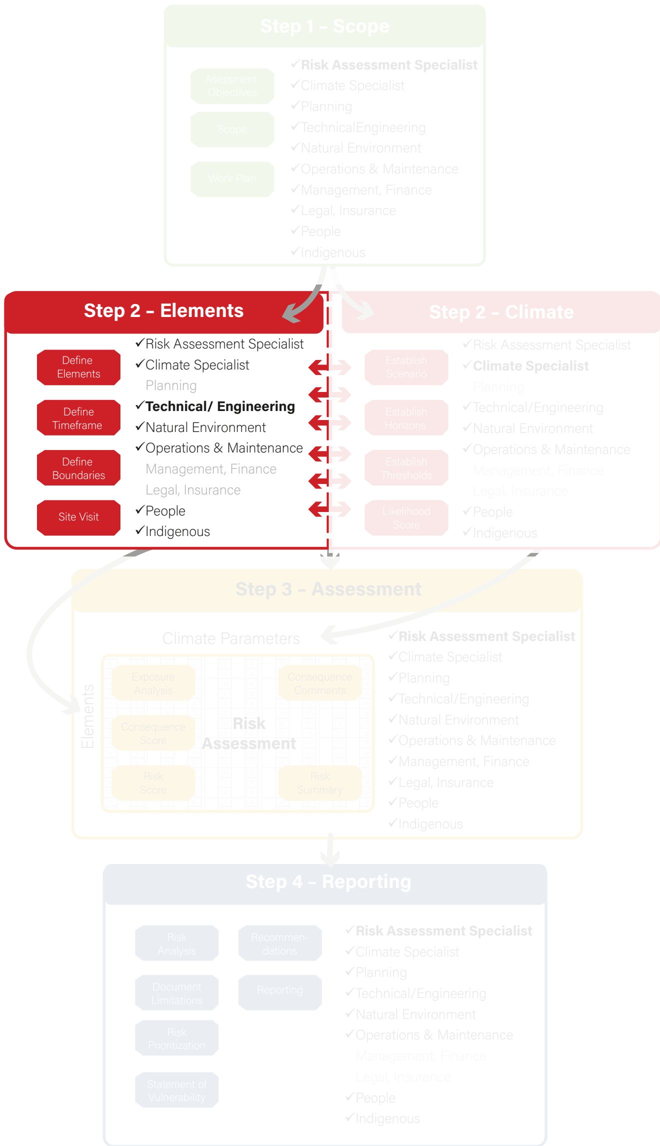
	Tasks	Timeframe	Assessment Team (shaded Team Members may not be required in that step of the project)	
Scope	**Project Overview** • Project Initiation • Understand assessment objectives • Confirm scope of assessment • Confirm work program and Schedule (Work Plan) • Designate roles and initiate information collection (Assessment Team)	**1 - 2 weeks** • Kick off meeting: 2 - 3 hours	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
Data	**Elements** • Defining Elements • Define Timeframe • Site Visit • Orientation Sessions (Presentation, Primers, Questionnaire)	**2 weeks** • Site Visit (half day – optional but recommended) • Orientation Sessions or Meetings (2 – 4 hours)	✓ Risk Assessment Specialist ✓ Climate Specialist ✓ Planning ✓ **Technical / Engineering (Lead)** ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
	Climate • Identify and Evaluate Climate Change and Climate Hazards and establish Climate Parameters • Establish Likelihood Scores	**2 weeks - may overlap with above** • Engagement / Meetings (2 – 3 hours)	✓ Risk Assessment Specialist ✓ **Climate Specialist (Lead)** ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
Assess	**Risk Assessment** • Establish Consequence Scores • Risk Assessment Workshop • Summarize and Classify Risk	**1- 2 weeks** • Half Day Workshop or Meeting (2 – 3 hours) depending on assessment approach	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
Report	**Recommendations Reporting** • Develop conclusions and recommendations for Identified risks • Review and Reporting	**1 - 4 weeks** Engagement / Meetings (2 – 3 hours)	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous

Assessment Team Tip In most PIEVC assessments Operation & Maintenance staff are key in providing specific local knowledge on how the assets and their specific elements have reacted to past extreme events and climate hazards.

Step 2a - Data - Elements

In this section you will:

- Define the Elements under assessment
- Assess Phases of Project and Life Cycle



Examples of Asset Categories and Elements are Included in the Appendix

Elements

As part of undertaking any assessment, it is important to identify and document the elements of a system or portfolio that may be vulnerable to the impacts of climate-related hazards. This process should be holistic and systematic to ensure critical elements are not mistakenly excluded from the **PIEVC HLSG** assessment. Of course, the final elements of a particular risk assessment will differ depending on the scale, geographic context and assets owned, operated and/or managed that are of interest. For example, at a municipal level, one could envision aligning these elements under assessment with the services provided to residents across the municipality as well as other elements that are particularly important for providing a continued level of service under climate change and extreme weather events.

The following describes categories of elements that may be assessed. Risk assessment leads are encouraged to review and identify those that may be particularly relevant based on their local geographic contexts and stakeholder perspectives.

Asset Category	Example
Built Infrastructure	• Buildings, Transportation Infrastructure, Energy and Electrical Infrastructure, Water Resources and Drainage, Water Supply, Treatment, Communication Infrastructure, Infrastructure, etc.
Natural Environment	• Green Infrastructure, Soils, Tree Canopy, Bioswales, etc. • Natural Systems • Natural Assets
People	• Includes all employees of an organization, also includes contractors, vendors, clients, customers, and other people that the organization chooses to classify in this category. In general, the term includes internal and external stakeholders of the organization that may be directly affected by the organization's risks and adaptation measures.

Element (Asset, Element, Sub Elements) should be summarized and included in the left hand column in the Risk Assessment Worksheet.

	Elements (E)
1	
2	

Phases of Project and Lifecycle

Defining the timeframes of an assessment involves aligning the expected lifecycle of the elements with climate projections and any data used to evaluate risk. Some suggested lifecycles for infrastructure elements are listed in the Table to the right as a starting point for an assessment. A more detailed analysis of infrastructure lifecycle is recommended as many factors affect lifecycle. The potential for infrastructure being repurposed, extending lifecycles beyond originally planned timeframes, should always be considered.

Elements	Expected Lifecycle*
• Dams/ Water Supply	• Base system 50-100 yrs. • Refurbishment 20-30 yrs. • Reconstruction 50 yrs.
• Storm/Sanitary • Sewer	• Base system 100 yrs. • Major upgrade 50 yrs. • Components 25-50 yrs.
• Roads/ • Bridges	• Road surface 10 -20 yrs. • Bridges 50-100 yrs. • Maintenance annually • Resurface concrete 20-25 yrs. • Reconstruction 50-100 yrs.
• Houses/ • Buildings	• Retrofit/alterations 15-20 yrs. • Demolition 50-100 yrs.

**Suggested lifecycles for infrastructure elements are listed as a starting point for an assessment. A more detailed analysis of infrastructure lifecycle is recommended as many factors affect lifecycle.*

Knowledge of the Elements Under Assessment

Specific knowledge of the elements under assessment is critical in an assessment. Local knowledge filtered through the overall expertise of the assessment team can help compensate for data gaps and provide a solid basis for professional judgment. In particular, local knowledge can provide insight about the nature of previous climatic events, their overall impact in the region and approaches used to address concerns. In addition, where possible, **traditional knowledge**, the collective knowledge of traditions used by Indigenous groups to sustain and adapt themselves to their environment over time, should be considered based on the objectives of the assessment.

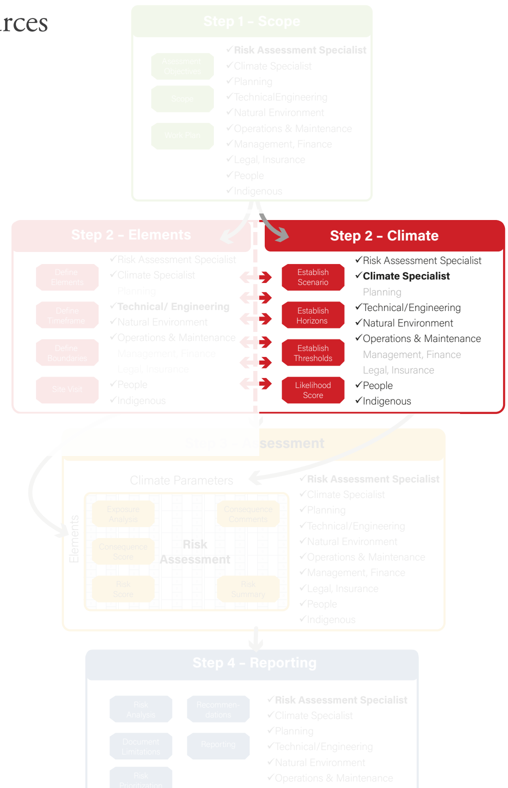
Often, local knowledge is gained through site visits to inspect and become familiar with the elements being assessed. These visits offer the opportunity to view facilities and pose questions to local maintenance, operations, and management staff, who can offer insight on the effects of events and remedial actions that may not have been fully captured in incident reports.

While not every **PIEVC HLSG** assessment may offer the opportunity to conduct site visits, it is important to gather as much local knowledge as possible through meetings and other consultations. Interviews and reviewing site photography are other approaches that can be employed in addition to or in replacement of a site visit.

Step 2b - Data - Climate

In this section you will:

- Select climate parameters and indicators for assessment
- Identify climate parameters, hazards and event likelihoods
- Establish the timescale of the assessment
- Develop climate parameters, hazards and indicators
- Source specific climate data and projections from credible data sources
- Establish likelihood scores for selected climate hazard indicators



Key Terms

Likelihood: Chance of something occurring; within the context of climate risk assessment, the chance of a defined climate hazard over a given time horizon.

Climate Scenario: A plausible representation of future climate that has been constructed for use to investigate the potential impacts of anthropogenic climate change. Various representations of climate scenarios exist from iterations of IPCC Reports, including Representative Concentration Pathways (RCP) from IPCC AR5 , Shared Socioeconomic Pathways (SSP) from IPCC AR6, and Global Warming Levels (GWL). While specific details surrounding scenarios may change with time, it is important to consider a range of scenarios in climate risk analysis. For example, RCP 8.5 from AR5 is considered a high scenario or 'business as usual scenario,' if past practices driving emissions continue. RCP 8.5 is used in many climate risk assessments. Scenario choice is often tied to risk appetite (tolerance) of the project team.

Identifying Climate Parameters, Hazards, Indicators, and Event Likelihoods

In this section the assessment team will determine the likelihood that future climate hazards will occur and interact with the elements under assessment. For the purposes of this guide, climate parameters are defined as the broad categories or groupings of measurable climate conditions, such as temperature, precipitation, and wind, among others. The terms climate hazards and indicators refer to the more specific impactful events that are likely to interact with a given asset or portfolio and create a measurable impact that can be described either quantitatively or qualitatively. These definitions align with International Standards.

When using the PIEVC HLSG it may be appropriate to utilize available datasets from national climate portals to provide screening level assessment data.

Timescale of the Assessment

The assessment team should select the boundaries and time horizons for assessment within the study. Typically, the time horizons for assessment are chosen to align with the **design life / expected lifecycle** of the infrastructure, or period of time before a planned retrofit or reassessment of climate impacts. When using the HLSG, the team should use a baseline (last 30 years of relevant climate hazard information or 1981 – 2010 normals period) and at least one future climate projection period for comparison. Any projected values are compared directly to the values established in the baseline to understand how likelihoods of hazards (individual or combined) are projected to change with respect to current frequency or intensity. Project-specific timeframes may also be considered depending on the assessment object and availability and complexity to obtain or develop them. Selection of time horizons should be done in tandem with the risk assessment and engineering teams.

Typical Climate Time Horizons are aligned with infrastructure lifecycles and refer to future 30-year periods in reference to the baseline period. In general, these periods include:

- 2020s (2011 – 2040) i.e. current conditions
- 2050s (2041 – 2070)
- 2080s (2071 – 2100)

Developing Climate Parameters, Hazards and Indicators

As previously noted, the terms climate parameter, climate hazard, and climate hazard indicator are central to the **PIEVC HLSG** process. Parameters describe the overall climate “categorization”, whereas the hazards and indicators describe more specific impactful events and the intensity thresholds at which impacts can be expected to occur on the elements under assessment.

Each climate parameter is assigned one or multiple associated hazards and hazard indicators that are specific to the infrastructure and elements under assessment.

Indicators can be identified using a variety of sources, including design standards, operational standards, rules of thumb, maintenance guidelines, codes of practice, literature, past impacts to the infrastructure under assessment, experience, and professional judgement. For each climate hazard, the team should define one or more corresponding indicator values associated with the performance thresholds of the infrastructure and provide these to the climate specialists for tailored climate analysis. When the PIEVC HLSG is applied to an asset in the design phase, historical climate of the site or region and prior impacts of climate on similar existing assets should be considered.

New data from the IPCC Sixth Assessment report (AR6) is now available, including a new set of GHG emissions scenarios. These scenarios correspond well with the current emissions scenarios from IPCC AR5, but should be reviewed by the team to determine the relevance of any new parameters and projections during the project timeline. New scenarios from AR6 are named Shared Socioeconomic Pathways (SSP) and combine the GHG forcing on the atmosphere with alternative pathways of socioeconomic development to include the effects of possible global strategies for mitigation, adaptation, and the impacts of climate change.

At the screening level, it may be possible to use pre-set climate indicators available from a series of climate portals. A list of potential climate indicator variables is available in the appendices.

Source Specific Climate Data and Projections

For the climate parameter list developed by the project team, data from nearby weather stations are used to establish a historical baseline for the assessment. Where historical data from observations is less available, the team climate specialist should consult multiple data sources to develop a historical baseline. Lack of available historical data for specific parameters should not deter the inclusion within the HLSG process.

Future climate projections use internationally recognized greenhouse gas (GHG) emissions scenarios (concentration pathways), adopted by the Intergovernmental Panel on Climate Change (IPCC). Although there are several GHG scenarios from the fifth assessment report (AR5) of the IPCC, the RCP8.5 high GHG emissions scenario is commonly used when assessing climate change risks to allow for a conservative assessment of risks posed by the changing climate and to align with current trends in global GHG emissions trajectories. Organizations may choose other scenarios based on their risk appetite, or multiple scenarios based on their project objectives.

The landscape of climate data availability within Canada has rapidly evolved, with access to datasets that are more organized for practitioners of multiple sectors. As a result, Canada has a number of data sources where historical climate data and future climate projections can be obtained. Climate data are now available in higher spatial and temporal resolution than ever before. However, remaining differences in availability of historical climate data sets may lead to gaps and “holes” in the overall understanding of baseline climate information for some climate parameters regardless of the state of new portals and gridded datasets. When this occurs, it is possible to use proxy datasets and modeled data to cover the gaps, particularly for temperature and precipitation related parameters. Careful evaluation of any data used within the **PIEVC HLSG** should be completed during this portion of the analysis, particularly around data availability for complex parameters (e.g., wind gusts, extreme and complex precipitation events, snowfall). From an analysis perspective, missing data should not deter the inclusion of relevant climate parameters, rather, it may require the use of alternative data sources (e.g., previous analyses, research papers, or specialized studies) or datasets, or less spatially explicit information (e.g., general findings of IPCC assessment reports applicable to the broader region), or expert opinion to conduct the climate analyses.

A short list of the main available climate portals is provided below. This list is not a comprehensive list of every data source in Canada but identifies certain key portals that can be consulted and used within the PIEVC HLSG framework.

Climate Portal Name	Source	Link
Climate Data Canada	Environment and Climate Change Canada/OURANOS/CRIM/PCIC/ Prairie Climate Centre	https://climatedata.ca
Downscaled Climate Scenarios	Environment and Climate Change Canada	https://climate-change.canada.ca/climate-data/#
Climate Atlas of Canada	Prairie Climate Centre	https://climateatlas.ca
PCIC Plan 2 Adapt	Pacific Climate Impacts Consortium	https://www.pacificclimate.org/analysis-tools/plan2adapt
PCIC Climate Explorer	Pacific Climate Impacts Consortium	https://www.pacificclimate.org/analysis-tools/pcic-climate-explorer
Ouranos Climate Portraits	Ouranos Consortium	https://www.ouranos.ca/climate-portraits

A good starting point for screening level climate information across Canada is the Climate Data Canada Portal. Additional portals are available for differing levels of needed detail, mainly through regional climate hubs that partner with the Canadian Centre for Climate Services. See PIEVC.CA for an up-to-date listing.

Outside of Canada, data are available from the US National Center for Environmental Information (NCEI) and the World Bank Climate Knowledge Portal, as well as through local climate service providers.

Establish Climate Parameters and Likelihood Scores

The following set of steps can be used to establish climate parameters and likelihood scores within the **PIEVC HLSG**:

- Identify the climate parameters, climate hazards, and climate hazard indicators of interest for the infrastructure elements under assessment.
  - Identify the climate hazards associated with the potential malfunction or failure of each infrastructure element.
  - Identify any combination of climate hazards that may result in infrastructure malfunction or failure.
    - Examples of combination events include rain on snow, high temperature coupled with high humidity, etc.
  - Establish for each climate hazard at least one indicator that represents the magnitude and/or duration of the hazard that could result in the malfunction or failure of the infrastructure element(s) under assessment.
    - For combination events, identify the indicator that is relevant to contributing climate hazards (e.g. for rain on snow events, the indicator could be based on a certain amount of rain and snow, or combined into a synthetic snow-water total equivalent). Indicators for malfunction or failure may be based upon codes, standards, constructed design values, engineering guidelines, operating or maintenance procedures, professional judgement and experience, or other relevant information. Be sure to provide robust justification or rationale where possible for the chosen climate indicator.

- For each climate hazard, determine whether an annual occurrence, or occurrence over the study time horizon, is of most concern.
  - For example, extreme rainfall events may cause recurring flooding issues whose risk would be more usefully evaluated based upon the annual probability of occurrence.
  - On the other hand, organizations should also consider the risks of extreme, rarer but more devastating events like ice storms or tornadoes. It is important to note that climate models may not be able to defensibly support estimates of future changes in the frequency or intensity of phenomena such as tornadoes and that other techniques may be required to arrive at such estimates
  - For these types of events, the low annual probability of occurrence in any given year is less telling but knowing about whether it could occur at least once over the study time would retain it within the organization's understanding of its risks.

> **Tornado**
> Check out Western University's Northern Tornadoes Project: www.uwo.ca/ntp and Figure I-10 in the National Building Code of Canada's Structural Commentaries (User's Guide – NBC 2015: Part 4 of Division B)).

- Using the methods in the Table below, determine Likelihood (L) scores. The process should be repeated for a baseline climate period and any future climate horizons selected. The primary method shown in the table below is referred to as the "middle-baseline" scoring method, which is seen as appropriate for a screening level assessment.

PIEVC Protocol Terms
In the PIEVC Protocol, Probability was used in place of Likelihood, and Severity was used in place of Consequence. In the PIEVC HLSG, Likelihood and Consequence are used to align with more widely used risk assessment processes.

- The "middle-baseline" scoring method assigns likelihood to hazard indicators by establishing the baseline conditions in the historical period (e.g. 1981 – 2010), with the mean conditions over this period being represented as a 3 in the scoring system. For example, if the climate hazard chosen is Days with Maximum Temperature over 35°C and historically, these occur 5 times per year, this would be represented in the baseline period by a 3 on the likelihood scale.

Likelihood Score (L)	Middle Baseline Approach - Establish Base	Method	Suggested Rationale
1	↑	Likely to occur less frequently than current climate	50 – 100% reduction in frequency or intensity with reference to Baseline Mean
2			10 – 50% reduction in frequency or intensity with reference to Baseline Mean
3	Establish Current Climate Baseline Per Parameter	Likely to occur as frequently as current climate	Baseline Mean Conditions or a change in frequency or intensity of ±10% with reference to the Baseline Mean
4			10 – 50% increase in frequency or intensity with reference to Baseline Mean
5	↓	Likely to occur more frequently than current climate	50 – 100%+ increase in frequency or intensity with reference to Baseline Mean

For the PIEVC HLSG, a simplified middle baseline likelihood scoring approach is proposed. For more detailed assessment including in the PIEVC Protocol, other scales and likelihood score assigning may be used.

- Using the time horizon(s) chosen for climate change projections, the scoring system allows for the scores to increase or decrease depending on the percent change from baseline frequency. For example, if Days with Maximum Temperature over 35°C increase from 5 times per year to 7 times per year (an increase from baseline of 40%), the score for this future time horizon is 4. If they increase to 12 times per year (140% from baseline), the score for the future time horizon is 5.

- The “middle-baseline” scoring scenario is flexible and allows for interpretation by the Project team.
- It is also appropriate to use other scoring systems, with appropriate documentation and justification for the choice made by the project team. For example, other methods such as Infrastructure Canada’s Climate Lens Guidance and the First Nations PIEVC (FN-PIEVC) method are useful for establishing likelihood scores.

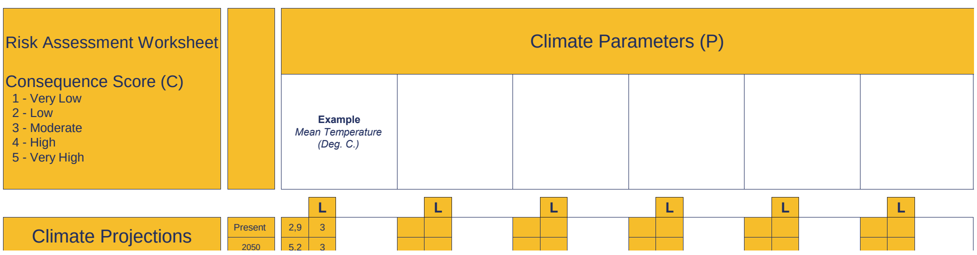
> The **FN-PIEVC** method was developed over a series of projects and workshops across Ontario to refine a flexible scoring method for assessments and aligns well with the comprehensive PIEVC scoring methods and the previous iterations of Infrastructure Canada’s Climate Lens Guidance.

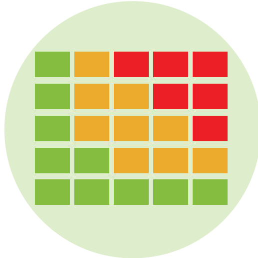
The climate likelihood scoring process can be completed separately from the consequence scoring exercise of the risk assessment. There are some key considerations for the likelihood scoring process that should be factored into each analysis. These key considerations are:

- Scoring is an iterative process, where hazard definitions and likelihood scores are developed by the climate specialist and reviewed with the project team. Time for revisions and consultation should be considered in the HLSG process.
- Hazards should not only include historically occurring hazards, but ones that could potentially manifest under future climate change. For example, if a region has never experienced maximum temperatures over 40°C historically but could within the assessment time horizons, this hazard should be included in analysis.
- Some hazards may require multiple indicators/thresholds as consequence of occurrence is not always proportional to event likelihood.
- Estimates of likelihood are sometimes based on climate parameters that are not perfect matches for the ones of interest by the project team. This is possible as likelihood scores represent a wide range of likelihoods within each “bin.”

In some cases, to avoid biasing the scoring process with a conflation between changes in likelihood and consequence, it is appropriate to withhold climate likelihood scores until after the consequence scoring is complete. Whether the two processes are completed separately before joining the results is a decision to be made by the project team.

Climate Parameters and Likelihood Scores (L) should be summarized and included in the top rows of the Risk Assessment Worksheet. This information will be used in later Steps of the Assessment.

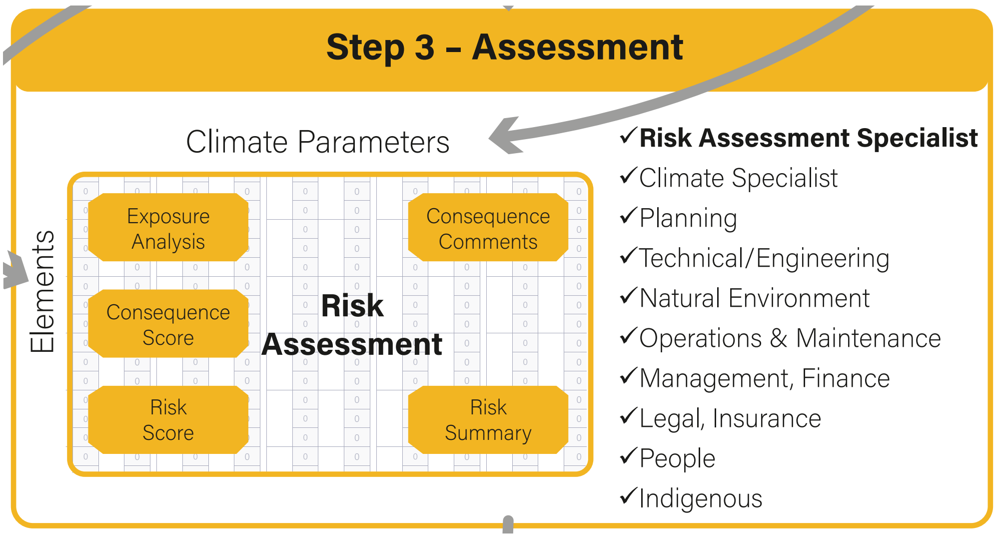


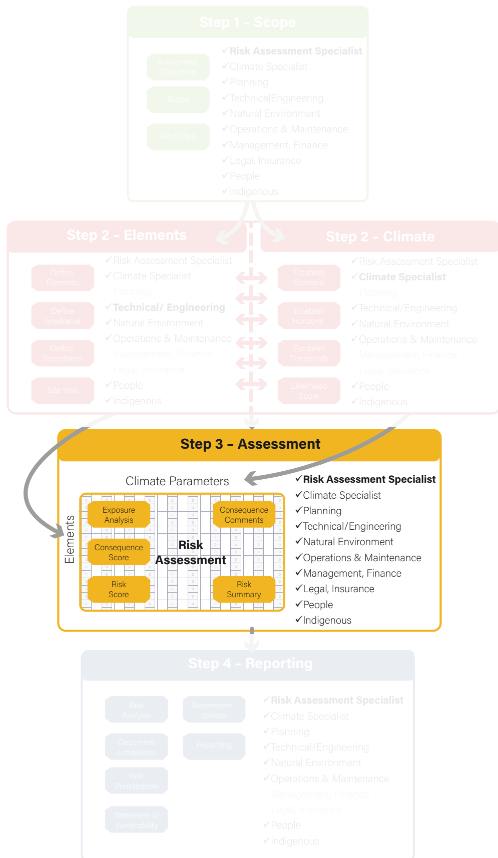


Step 3 – Assess

In this section you will:

- Assess and Evaluate climate change risks
- Conduct a risk assessment to assess the consequence of each **Element's (E)** interaction with the selected **Climate Parameters (P)**
- Calculate, summarize and evaluate the Risk (R) for each interaction





Risk Assessment

Complete a Risk Assessment using:

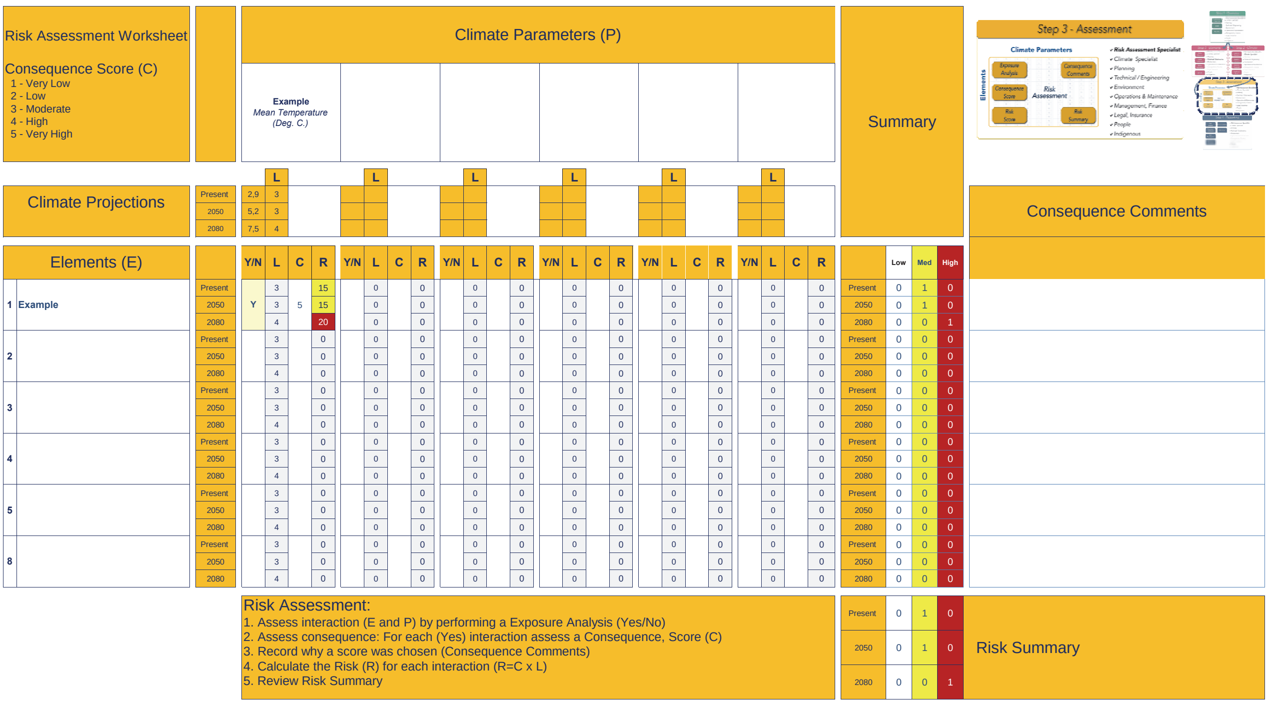
- **Elements (E)** developed in Step 2
- **Climate Parameters (P)** and **Likelihood Scores (L)** developed in Step 2
- **Risk (R) = Exposure (E) x Consequence (C) x Likelihood (L)**

Considerations for Portfolio Assessments

In larger assessments, including portfolio assessments with multiple locations, several worksheets, databases or GIS tools maybe a preferred method of recording the risk assessment results.

Risk Assessment using a Risk Assessment Worksheet

In most **PIEVC HLSG** applications, this work will be recorded on a risk assessment worksheet during a multi stakeholder risk assessment workshop.



Risk Worksheet
In most applications a risk worksheet or set of worksheets will be used. In other applications with a larger number of Elements, a database, GIS or other application tool maybe used (see examples in appendix).

Resources are included in the Appendix.

- Sample Risk Matrix (Excel Version)

Exposure Analysis

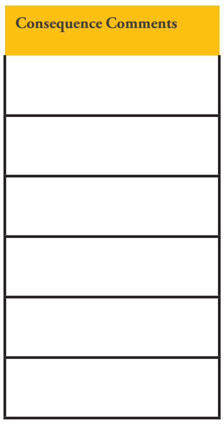
Assess interaction of Portfolio elements and climate parameters by performing an **Exposure (Yes/No) Analysis.**

Assess Consequence

Assess consequence: For each **(Yes)** interaction assess a **Consequence, Score (C)**

Documentation of the selected consequence scores for each element will assist in understanding the risk scores as well as assist in developing recommendations later in the assessment. Comments may describe effects, measurable outcomes (e.g. how it affects the operational goal, duration of outage, safety, critical infrastructure loss, financial, environmental effect, reputation, etc.). Organizations may choose other scales based on their project objectives.

Consequence Score (C)	
1	Very Low
2	Low
3	Moderate
4	High
5	Very High



Consequence Comments

The risk worksheet provides an area to document comments. This will assist in development of recommendations in later steps and help when the assessment is updated in the future or when the results are provided to a third party.

Develop Risk Score

- Calculate the **Risk (R) for each interaction Risk (R) = Exposure (E) x Consequence (C) x Likelihood (L)**, where **(E)** is either **Yes=1** or **No=0**

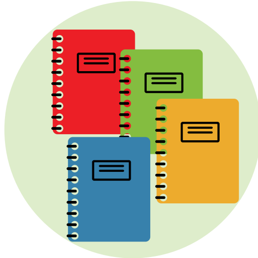
Summarize the Risks

Summarize and classify risk using the scales provided. Assessors may adjust the classification categories as appropriate to align with the infrastructure owner's risk appetite.

Risk Score (R)	Risk Classification		
1 - 9		Low Risk	Risks requiring minimal action
10 - 16		Medium Risk	Risk that may require further action
17 - 25		High Risk	Risks that require action

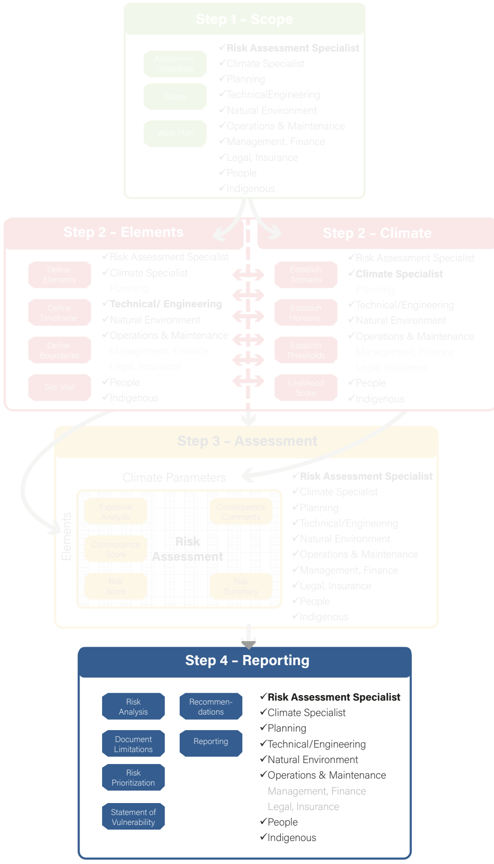
5	Consequence	5	10	15	20	25
4		4	8	12	16	20
3		3	6	9	12	15
2		2	4	6	8	10
1		1	2	3	4	5
		Likelihood				
		1	2	3	4	5

Step 4 – Report



In this section you will:

Evaluate and assess risk treatment, develop recommendations and prepare reports.



Key Terms

Adaptation: Process of adjustment to actual or expected climate and its effects.

Residual Risk: Risk remaining after risk treatment.

Risk Tolerance: Readiness to bear the risk after risk treatment.

Risk Treatment: Process to modify risk.

Project Boundaries

A statement of assumptions and limitations explains the boundaries of the assessment in time and in space and offers a sense of the data sensitivities encountered. It provides clarity and guidance on the overall confidence in the work.

Evaluate and Assess the Risk

- Prepare a Statement of Assumptions and Limitations
- What was and was not considered?
- Which timeframes were considered?
- Which RCPs or future scenarios were used?
- Comment on missing, unavailable data and uncertainty.
- Comment on steps taken to address missing or unavailable data.
- Categorize and prioritize risk:
  - **Low, Medium and High**
  - Consider other factors that may be used to classify risk into priorities.
    - Consider timing, cost, available resources, finance, legal, O&M, risk tolerance, etc.

  - Identify and discuss special case risks:
    - Low Likelihood – High Consequence that could represent significant concerns, despite low risk assessment scores.
    - High Likelihood – Low Consequence that could represent significant concerns, despite low risk assessment scores.

- Based on the prioritization, identify:
  - Interactions that require no action at this time (Low Risk).
  - Interactions that may require further attention, study over time (Medium Risk).
  - Interactions that require immediate action (High Risk).
  - Special case risks.

- Prepare a Concluding Statement that identifies:
  - The overall level of confidence in the assessment based on the level of detail.
  - Context regarding the level of assessment and application of findings.
  - The amount of vulnerability or resiliency of the system.
  - The global limitations of the assessment.
  - The time horizon of the assessment.
  - Climate trends that contribute to the vulnerability of the system.

Concluding Statement
This infrastructure is generally resilient to changing climate impacts anticipated over the next twenty years with the exception of "xxx" that is vulnerable to projected changes in "yyy" over that time horizon. This opinion is based on information available at the time of the assessment.

Portfolio Considerations in Analyzing Risks

- Identify patterns of risk across Portfolio Assets and Elements.
- Identify Assets with High Priority that require action.
- Identify risks that can be generalized and may therefore be relevant to non-assessed Assets.
- Identify Portfolio Wide risks.
- Summarizing risks based on the objective of the assessment (e.g., Top/Highest Risk Sites).
- Identify geographical hazards and related risks.
- Identify unique climate zone risks.
- Identify the amount of vulnerability or resiliency of the Portfolio considering:
  - The global limitations of the assessment.
  - The time horizon of the assessment.

Develop Recommendations

- Develop recommendations for identified risks.
  - Provide justification for each recommendation.
  - Incorporate, as much as possible, organization risk tolerance and acceptable residual risk.

- Categorize the recommendations according to for example:
  - Policy/procedural changes.
  - Remedial actions.
  - Further study or analysis.
  - More comprehensive risk assessment (e.g. using the full PIEVC Protocol).
  - Engineering design considerations to engineering analysis, preliminary design criteria or design changes.
  - Risk avoidance strategies.
    - Consider stopping activities in high-risk areas.
  - Other, as appropriate.

- Discuss next steps and the frequency and nature of monitoring and review of risks.

Risk Communication
The results of the assessment may be incorporated into existing or planned organizational risk management plans. The risk communication plan establishes who should be informed of the recommendations, the timing of follow-up assessments, and other relevant factors to aid in overall organizational risk management.

Prepare Reports

- Based on identified recommendations, as necessary, prepare or integrate risk information into:
  - Executive Summary Reports.
  - Technical Reports.
  - Presentations.
  - Asset Management Plans.
  - Capital Plans.
  - As appropriate, include and highlight statements of Vulnerability and Resiliency.
  - A stand-alone report on the results of the screening may be required by the client/owner or as part of an application or review process. In such cases, documentation of each step, including assumptions, limitations and methods used to estimate risk should be fully disclosed.

Reporting Team and Competency

Reporting is a coordinated effort drawing on the assessment team expertise of:

- Technical / Engineering
- Risk
- Climate

The lead role in coordinating and directing reporting efforts should have familiarity with the elements assessed, climate analysis and the PIEVC HLSG process.

Bibliography / References

- Prepare a bibliography of key references and materials necessary to support the assessment work.
  - The bibliography should identify key procedures, methodologies, standards, and other relevant documents that the team used to guide and inform the assessment.

Adapt

Next Steps after a screening assessment:

- Project evaluation, selection and approval
- Development of adaptation plans
- Asset Management Planning
- Master and Capital Planning
- More detailed Risk Assessment and Engineering Analysis

Appendix

- Glossary
- Example Projects:
  - Single and Portfolio

- Supporting Documents
  - Examples of Assets, Infrastructure Categories, Elements and Climate Parameters
  - Example Climate Report
  - Sample Climate Report Template
  - Sample Risk Assessment Worksheet (Excel version)

Website Resources (PIEVC.CA)

- Other PIEVC Products
- Additional Example Projects and Details
- List of climate resources

Appendix - Glossary

Vocabulary	Definition	Source
Adaptation	Process of adjustment to actual or expected climate and its effects. • In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. • In some natural systems, human intervention can facilitate adjustment to expected climate and its effects.	ISO 14090 IPCC
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.	ISO 14090 IPCC
Climate Hazard	Specific impactful event as related to the broader climate parameter category	
Climate Hazard Indicator	Specific climate values (Maximum Temperature > 35 C; Precipitation > 100mm; Freezing Rain > 30 mm, etc.)	ISO 14090
Climate Parameter	Broader categories of climate that contain specific climate hazards or indicators. Climate parameters include temperature, precipitation, sea-level rise, wind, etc.	ISO 14090 IPCC
Climate Scenario	A plausible representation of future climate that has been constructed for use to investigate the potential impacts of anthropogenic climate change. Various representations of climate scenarios exist from iterations of IPCC Reports, including Representative Concentration Pathways (RCP) from IPCC AR5 , Shared Socioeconomic Pathways (SSP) from IPCC AR6, and Global Warming Levels (GWL). While specific details surrounding scenarios may change with time, it is important to consider a range of scenarios in climate risk analysis. For example, RCP 8.5 from AR5 is considered a high scenario or 'business as usual scenario,' if past practices driving emissions continue. RCP 8.5 is used in many climate risk assessments. Scenario choice is often tied to risk appetite of the project team and/or sponsoring organization.	Climate Risk Institute
Consequence	Outcome of an event affecting objectives. • An event can lead to a range of consequences. • A consequence can be certain or uncertain and can have positive or negative effects on objectives. • Consequences can be expressed qualitatively or quantitatively.	ISO Guide 73
Element	A distinct part of a composite system. Could include physical, planning or human resources.	ISO 14090
Engineering Vulnerability	The shortfall in the ability of public infrastructure to absorb the negative effects, and benefit from the positive effects, of changes in the climate conditions used to design and operate infrastructure.	PIEVC
Enterprise Risk Management	The culture, capabilities, and practices, integrated with strategy-setting and its performance, that organizations rely on to manage risk in creating, preserving, and realizing value.	COSO

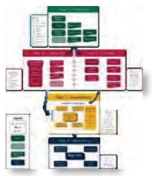
Vocabulary	Definition	Source
Likelihood	Chance of something happening. • In risk management terminology, the word "likelihood" is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically. • The English term "likelihood" does not have a direct equivalent in some languages; instead, the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, "likelihood" is used with the intent that it should have the same broad interpretation as the term "probability" has in many languages other than English.	ISO Guide 73
Portfolio	A range of assets held by a person or organization.	Oxford English Diction-ary
Probability	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty.	ISO Guide 73
Public Risk	The possibility that human actions, or events lead to consequences that harm aspects that humans value.	PRIMO
Residual Risk	Risk remaining after risk treatment Residual risk can contain unidentified risk. Residual risk can also be known as "retained risk".	ISO Guide 73
Resilience	The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.	IPCC
Risk	Effect of uncertainty An effect is a deviation from the expected. It can be positive, negative or both. An effect can arise as a result of a response, or failure to respond, to an opportunity or threat related to objectives. Uncertainty is the state, even partial, of deficiency of information retal-iated to, understanding, or knowledge of, an event, its consequence, or likelihood. This guide applies the following formula as a measure of risk. Risk = Exposure x Likelihood x Consequence.	ISO 14090
Risk Appetite	Amount and type of risk that an organization is willing to pursue or retain.	ISO Guide 73
Risk Owner	Person or entity with the accountability and authority to manage a risk.	ISO Guide 73

Vocabulary	Definition	Source
Risk Profile	Description of any set of risks The set of risks can contain those that relate to the whole organization, part of the organization, or as otherwise defined.	ISO Guide 73
Risk Tolerance	Organization's or stakeholder's readiness to bear the risk after risk treatment in order to achieve its objectives. Risk tolerance can be influenced by legal or regulatory requirements.	ISO Guide 73
Risk Treatment	Process to modify risk • Risk treatment can involve: - Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk - Taking or increasing risk in order to pursue an opportunity - Removing the risk source - Changing the likelihood - Changing the consequences - Sharing the risk with another party or parties [including contracts and risk financing] - Retaining the risk by informed decision • Risk treatments that deal with negative consequences are sometimes referred to as "risk mitigation", "risk elimination", "risk prevention" and "risk reduction". • Risk treatment can create new risks or modify existing risks.	ISO Guide 73
Traditional Knowledge	Although there is no universally accepted definition of "traditional knowledge", the term is commonly understood to refer to collective knowledge of traditions used by Indigenous groups to sustain and adapt themselves to their environment over time. This information is passed on from one generation to the next within the Indigenous group. Such Traditional Knowledge is unique to Indigenous communities and is rooted in the rich culture of its peoples. The knowledge may be passed down in many ways, including Storytelling, Ceremonies, Dances, Traditions, Arts and Crafts, Ideologies, Hunting, Trapping, Food Gathering, Food Preparation and Storage, Spirituality, Beliefs, Teachings, Innovations, Medicines. Traditional Knowledge is usually shared among Elders, healers, or hunters and gatherers, and is passed on to the next generation through ceremonies, stories or teachings.	Assembly of First Nations
Threshold	Point beyond which a system is deemed to be no longer effective: Economically; Socially; Technologically; or Environmentally. Also known as tipping point.	ISO 14090
Vulnerability	Propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.	ISO 14090 IPCC

Appendix - Example Projects

Example Project 1
Single Asset Assessment

City of Clean River New Wastewater Treatment Plant



The City of Clean River applied for funding under the Investing in Canada Infrastructure Program (ICIP) program for a new wastewater treatment plant and works. The project replaces an existing wastewater treatment Lagoon which is out of compliance. The City was informed that the project was short-listed under the ICIP grant funding. One of the requirements to secure funding contributions and final approval is for the City to complete a Climate Lens Assessment. A Consultant was engaged by the City to complete the Climate Change Resilience portion of the Climate Lens Assessment. The Consultant had recently completed the detailed design of the proposed works and had considerable local knowledge having worked in the community for many years. The specialists involved in the design were included as subject matter experts in the assessment as well as a senior climatologist. The City allocated resources to assist in the assessment including a risk assessment workshop. The Consultant used the PIEVC HLSG to meet the requirements of the Climate Lens Resilience Assessment. The Risk Assessment Specialist signed the Attestation for the assessment.

Step 1 - Overview

Assessment Objectives

Objective: Climate Resilience Assessment meeting the requirements of ICIP grant requirements for a Climate Lens Assessment for the City of Clean River new wastewater treatment plant and works.

Scope

PIEVC HLSG assessment: wastewater treatment plant and works. Work includes assessment of existing Infrastructure (sewer collection and lift stations) and the proposed wastewater treatment plant based on a tender ready design. Location: City of Clean River, Design horizon to 2050 with lifecycle of ~ 30 to 75 years

Work Plan

Schedule: Project to be completed over 2 month period with a project Initiation meeting, site visit and orientation session, risk workshop and recommendations review. Consultant to finalize report and provide attestation.
Assessment Team: Risk Assessment Specialist (Consultant), Climate Specialist (Consultant), Technical / Engineering (consultant and City), Operation & Maintenance (City), Management, Finance (City Councillor and CAO),

Step 2 - Elements

Wastewater Treatment Facility	Conveyance Infrastructure, Utilities
Below Grade Elements	Waterworks Infrastructure
Slopes	Sewer Infrastructure
Outfall	Electrical Infrastructure
Electrical Infrastructure / Standby Power	Exterior IT / Communications Infrastructure
IT / Communications	Pump Stations Infrastructure (x4)
HVAC	
Process Mechanical Equipment	**People**
Buildings Envelope + Roof	Public perception
Structure	O&M
Landscaped Areas (incl. trees)	
Stormwater / Drainage Infrastructure	

Step 2 - Climate

Recent past (1976-2005), short-term (2021-2050) and long-term (2051-2080) future climate horizons. Source: PCIC

Climate Parameters	
Sea level rise	High intensity persistent rains
Hot summer temperature	Total precipitation
Heat waves	Drought
Cold winter temperatures	Inland snowfall
Freezing conditions	High winds
High intensity short duration rains	Fires

Climate Parameters

Powell River CWWTF

Climate Parameter		Present Est. Value	Present Likelihood Score	2050s Est. Value	2050s Likelihood Score	2080s Est. Value	2080s Likelihood Score	Occurrence Definition	RCP Scenario	Parameter source	Direction Confidence	Magnitude Confidence	
Sea level rise	Regional relative sea level change relative to present day (cm)	0	3	50	4	90	5	Occurrence over time horizon	RCP8.5	Geological Survey of Canada: Relative Sea-level Projections in Canada and the Adjacent Mainland United States (2014)	High	Low	[illegible]
Hot summer temperatures	Average days per year above 30°C (days)	0.5	1	7	3	20	4	annual occurrence	RCP8.5	Climate Atlas of Canada (underlying: PCIC climate data)	High	High	[illegible]
Heat waves	Warmest maximum temperature (°C)	29	3	33	4	35	5	annual occurrence	RCP8.5	Climate Atlas of Canada (underlying: PCIC climate data)	High	High	[illegible]
Cold winter temperatures	Average coldest daily minimum winter temperature (°C)	-7.5	3	-4.7	2	-2.6	1	annual occurrence	RCP8.5	Climate Atlas of Canada (underlying: PCIC climate data)	High	High	[illegible]
Freezing conditions	Average number of frost days per year (days)	46	3	15	2	4	1	annual occurrence	RCP8.5	Climate Atlas of Canada (underlying: PCIC climate data)	High	High	[illegible]
High intensity short duration rains	1-in-100 year annual maximum 1 hour precipitation accumulation (mm)	31.41	3	41	4	43	5	Occurrence over time horizon	RCP8.5	IDF-CC (underlying: PCIC climate data)	High	Medium	[illegible]
High intensity, persistent rains	Precipitation as rain: average annual 5-day maximum total (mm)	95	3	110	4	117	5	annual occurrence	RCP8.5	BC Climate Data Explorer (underlying: PCIC climate data)	High	Medium	[illegible]
Total precipitation	Total annual precipitation (mm)	1247	3	1286	4	1355	5	annual occurrence	RCP8.5	Climate Atlas of Canada (underlying: PCIC climate data)	High	Medium	[illegible]
Drought	Average number of consecutive days with <1 mm rain (days)	23	3	29	4	35	5	annual occurrence	RCP8.5	BC Climate Data Explorer (underlying: PCIC climate data)	High	Low	[illegible]
Snowfall	Inland precipitation as snow (mm)	2193	5	1550	4	1029	3	annual occurrence	RCP8.5	ClimateBC	High	High	[illegible]

Step 3 - Assessment

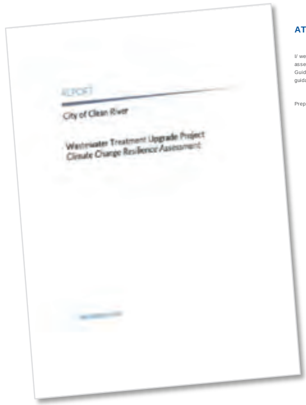
Clean River WWTP Risk Assessment Worksheet

						Climate Parameter																																	
						Sea Level Rise				Hot summer temperatures				Heat Wave				Cold winter temperatures				Freezing Conditions				High intensity short duration rain				High intensity persistent rains				Total Percipitation				Drou	
	Infrastructure Components		Low	Med	High	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L
	Conveyance Infrastructure, Utilities																																						
1	Waterworks Infrastructure	Present	6	1	0		3				1		2		3		6		3		3		3		6		3				3				3				3
		2050	6	1	0	N	4			Y	3	2	6	Y	4	2	8	Y	2	1	2	Y	2	2	4	N	4			N	4			N	4			Y	4
		2080	4	2	1		5				4		8		5		10		1		1		1		2		5				5				5				5
2	Sewer Infrastructure	Present	4	0	0		3		6		1				3				3				3				3		6		3		6		3				3
		2050	4	0	0	Y	4	2	8	N	3			N	4			N	2			N	2			Y	4	2	8	Y	4	2	8	N	4			N	4
		2080	1	3	0		5		10		4				5				1				1				5		10		5		10		5				5
3	Electrical Infrastructure	Present	4	0	0		3				1		1		3		6		3				3				3				3				3				3
		2050	4	0	0	N	4			Y	3	1	3	Y	4	2	8	N	2			N	2			N	4			N	4			N	4			N	4
		2080	2	2	0		5				4		4		5		10		1				1				5				5				5				5
4	Exterior IT / Communications Infrastructure	Present	1	0	0		3		3		1				3				3				3				3				3				3				3
		2050	1	0	0	Y	4	1	4	N	3			N	4			N	2			N	2			N	4			N	4			N	4			N	4
		2080	1	0	0		5		5		4				5				1				1				5				5				5				5
5	Pump Stations Infrastructure	Present	5	0	0		3		9		1		2		3		6		3				3				3		6		3		6		3				3
		2050	4	1	0	Y	4	3	12	Y	3	2	6	Y	4	2	8	N	2			N	2			Y	4	2	8	Y	4	2	8	N	4			N	4
		2080	1	4	0		5		15		4		8		5		10		1				1				5		10		5		10		5				5
	Consolidated WWTF, incl. Admin Building, Process Building, and Bioreactor Complex (+ gallery)																																						
6	Below Grade Elements incl. Outfall	Present	3	0	0		3		6		1				3				3				3				3		3		3		3		3				3
		2050	3	0	0	Y	4	2	8	N	3			N	4			N	2			N	2			Y	4	1	4	Y	4	1	4	N	4			N	4
		2080	2	1	0		5		10		4				5				1				1				5		5		5		5		5				5
7	Slopes	Present	7	0	0		3				1		3		3		9		3				3				3		9		3		9		3		3		3
		2050	4	3	0	N	4			Y	3	3	9	Y	4	3	12	N	2			N	2			Y	4	3	12	Y	4	3	12	Y	4	1	4	Y	4
		2080	1	6	0		5				4		12		5		15		1				1				5		15		5		15		5		5		5
8	Electrical Infrastructure / Standby Power	Present	4	0	0		3				1		2		3		6		3				3				3				3				3				3
		2050	4	0	0	N	4			Y	3	2	6	Y	4	2	8	N	2			N	2			N	4			N	4			N	4			N	4
		2080	2	2	0		5				4		8		5		10		1				1				5				5				5				5
9	IT / Communications	Present	3	0	0		3				1		1		3		6		3				3		3		3				3				3				3
		2050	3	0	0	N	4			Y	3	1	3	Y	4	2	8	N	2			Y	2	1	2	N	4			N	4			N	4			N	4
		2080	2	1	0		5				4		4		5		10		1				1		1		5				5				5				5
10	HVAC	Present	5	0	0		3				1		2		3		9		3		3		3		3		3				3				3				3
		2050	3	2	0	N	4			Y	3	2	6	Y	4	3	12	Y	2	1	2	Y	2	1	2	N	4			N	4			N	4			N	4
		2080	3	2	0		5				4		8		5		15		1		1		1		1		5				5				5				5
	Mechanical Equipment (pumps, screens &	Present	6	0	0		3				1		2		3		9		3		3		3		3		3		3		3		3		3				3

Risk Summary		Low	Med	High
	Present	81	5	0
	2050	66	20	0
	2080	42	39	5

Step 4 - Reporting

	Infrastructure	Risk Comments	Recommendations
	Conveyance Infrastructure, Utilities		
1	Waterworks Infrastructure (incl. Fire Protection Hydrants)	Increasing risk of temperature, drought, and fire affecting the infrastructure. The affected infrastructure is used to mitigate against fires (hydrants, watermains). This is considered in the current design.	City to develop Fire Protection Plan. No risk mitigation is required beyond the current design.
2	Sewer Infrastructure	Some medium risk of sea level rise (leading to erosion) and intense rainfall events, affecting the infrastructure. The effect timeframe is beyond the current design horizon of the infrastructure. Infrastructure will be re-assessed and upgraded if required based on actual conditions at that time. This is built in adaptive capacity and considered in the current design (as demonstrated by the low risk at present and in 2050).	No risk mitigation is required beyond the current design.
3	Electrical Infrastructure	Some medium risk of high temperature and fires affecting the infrastructure. The effect timeframe is beyond the current design horizon of the infrastructure. Infrastructure will be re-assessed and upgraded if required based on actual conditions at that time. This is built in adaptive capacity and considered in the current design (as demonstrated by the low	No risk mitigation is required beyond the current design.

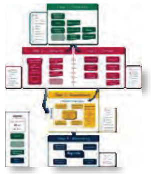


ATTESTATION FOR RESILIENCE ASSESSMENT

Prepared by:

Example Project 2 Portfolio Asset Assessment

City of Clean River



The City of Clean River engaged a consultant to complete a climate risk and vulnerability assessment for a portfolio of municipal assets within the following areas:

- Stormwater
- Water and Wastewater
- Buildings and Facilities
- Electricity
- Roads, Fleet, and Transit
- Environment

The assessment applied the PIEVC High Level Screening Tool to identify high risks to the City's infrastructure resulting from climate change and identified adaptive measures for the City to consider in future decisions around land use planning, building construction, infrastructure assessment, and programming. The assessment was completed with input from City Staff in a series of workshops.

Step 1 - Overview

Assessment Objectives

Objective: Complete a climate risk and vulnerability assessment for a portfolio of municipal assets to identify high risks to the City's infrastructure resulting from climate change and identify adaptive measures to consider in future decisions around land use planning, building construction, infrastructure assessment, and programming.

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Scope

PIEVC HLSG assessment: Stormwater, Water and Wastewater, Buildings and Facilities, Electricity, Roads, Fleet, and Transit and Environment. Location: City of Clean River, Design horizon to 2050 with lifecycle of ~ 30 to 100 years.

Work Plan

Schedule: Project to be completed over 4 month period with a project Initiation meeting and orientation session, risk workshops for each asset area, risk review adaptation planning meetings. Work completed in both face-to-face and virtual meetings and workshops. **Assessment Team**: Risk Assessment Specialist (Consultant), Climate Specialist (Consultant), Technical / Engineering (consultant and City) for each asset area, Operation & Maintenance (City) for each asset area, Management, Finance (City Councilor and CAO)

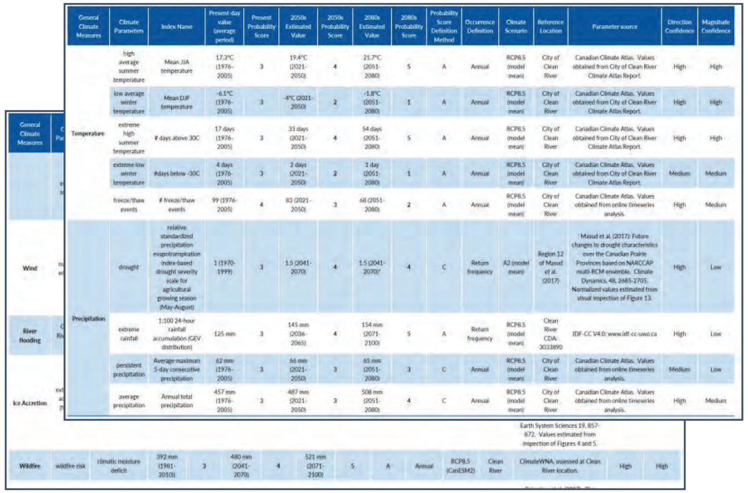
Step 2 - Elements

Buildings and Facilities	Electric Utility Components	Roads, Fleet, and Transit Infrastructure	Environment	Water and Wastewater	Stormwater Infrastructure
Buildings and Facilities	**Transmission System**	**Roads**	**Parks and Open Spaces**	**Water Plant**	**Storm Ponds**
Staff	Staff	Staff	Staff	Staff	Staff
Landscaped Areas	Transmission Lines	Roadways	Public	River and Intake	Dry ponds
Utilities	Substations	Laneways and Sidewalks	Wildlife	Treatment	Wet ponds
Structure and Envelope	Substation Buildings	Bridges	Turf	Building / HVAC / Electrical	Lift stations
HVAC	Grid Inter-Connections	Signals, Signs, Lights	Forestry	**Distribution**	**Gravity Collection**
Real Estate and Land	Communication	Rail Lines and Crossings	Pathways	Staff	Staff
For Sale	**Distribution System**	**Fleet**	Amenities	Water Distribution Lines	Catch basins
For Development	Staff	Staff	Roads and Parking	Reservoirs	Collection systems
	Transformers	Fleet Vehicles	Facilities	**Wastewater Plant**	Storm Service Lines
	Overhead Lines	Fleet Facility	Irrigation	Staff	**Outfalls**
	Underground Lines	**Transit**	Lakes and Ponds	Headworks	Staff
	Communication	Staff		Treatment	Outfalls
		North Terminal		Building / HVAC / Electrical	
		Transit Buses		**Collection**	
		Communication Systems		Staff	
				Lift Stations / Forcemains	
				Gravity Sewers	

Step 2 - Climate

1976-2005, 2021-2050, 2051-2080.
Source: PCIC.

Temperature
High Average Summer Temperature
Low Average Winter Temperature
Extreme High Summer Temperature
Extreme Low Winter Temperature
Freeze/Thaw Events
Precipitation
Drought
Extreme Rainfall
Persistent Precipitation
Extreme Snowfall
Hail Days
Average Precipitation
Maximum Wind Gust
River Flooding
Freezing Rain
Wildfire
Tornado

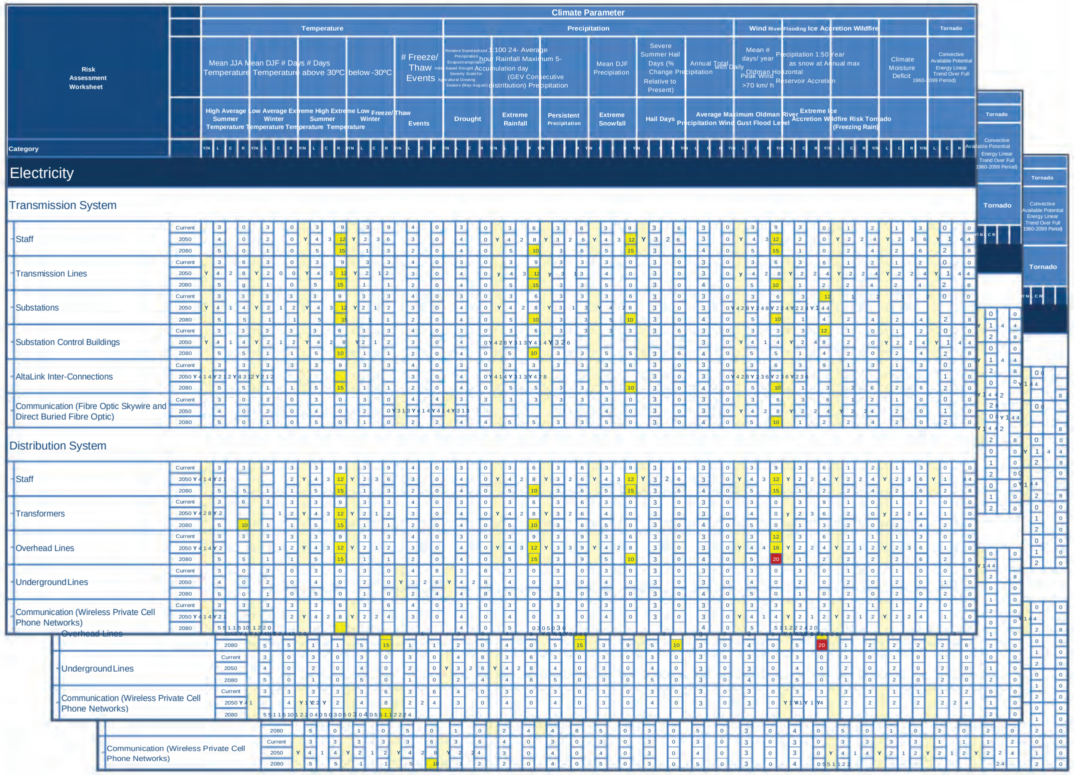


General Climate Measures	Climate Parameters	Index Name	Present-day value (average period)	Present Probability Score	2050s Estimated Value	2050s Probability Score	2080s Estimated Value	2080s Probability Score	Probability Score Definition Method	Occurrence Definition	Climate Scenario	Reference Location	Parameter source	Direction Confidence	Magnitude Confidence
Temperature	high average summer temperature	Mean JJA temperature	17.3°C (1976-2005)	3	19.4°C (2021-2050)	4	21.7°C (2051-2080)	5	A	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from City of Clean River Climate Atlas Report.	High	High
	low average winter temperature	Mean DJF temperature	-6.1°C (1976-2005)	3	-4°C (2021-2050)	2	-1.8°C (2051-2080)	1	A	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from City of Clean River Climate Atlas Report.	High	High
	extreme high summer temperature	# days above 30C	17 days (1976-2005)	3	33 days (2021-2050)	4	54 days (2051-2080)	5	A	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from City of Clean River Climate Atlas Report.	High	High
	extreme low winter temperature	#days below -30C	4 days (1976-2005)	3	2 days (2021-2050)	2	1 day (2051-2080)	1	A	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from City of Clean River Climate Atlas Report.	Medium	Medium
	freeze/thaw events	# freeze/thaw events	99 (1976-2005)	4	83 (2021-2050)	3	68 (2051-2080)	2	A	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from online timeseries analysis.	High	Medium
Precipitation	drought	relative standardized precipitation evapotranspiration index-based drought severity scale for agricultural growing season (May-August)	1 (1970-1999)	3	1.5 (2041-2070)	4	1.5 (2041-2070)*	4	C	Return frequency	A2 (model mean)	Region 12 of Masud et al. (2017)	Masud et al. (2017): Future changes to drought characteristics over the Canadian Prairie Provinces based on NARCCAP multi-RCM ensemble. Climate Dynamics, 48, 2685-2705. Normalized values estimated from visual inspection of Figure 13.	High	Low
	extreme rainfall	1:100 24-hour rainfall accumulation (GEV distribution)	125 mm	3	145 mm (2036-2065)	4	154 mm (2071-2100)	5	A	Return frequency	RCP8.5 (model mean)	Clean River CDA 3033890	IDF-CC V4.0: www.idf-cc-uwo.ca	High	Low
	persistent precipitation	Average maximum 5-day consecutive precipitation	62 mm (1976-2005)	3	66 mm (2021-2050)	3	65 mm (2051-2080)	3	C	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from online timeseries analysis.	Medium	Low
	average precipitation	Annual total precipitation	457 mm (1976-2005)	3	487 mm (2021-2050)	3	508 mm (2051-2080)	4	C	Annual	RCP8.5 (model mean)	City of Clean River	Canadian Climate Atlas. Values obtained from online timeseries analysis.	High	Medium

General Climate Measures	Climate Parameters	Index Name	Present-day value (average period)	Present Probability Score	2050s Estimated Value	2050s Probability Score	2080s Estimated Value	2080s Probability Score	Probability Score Definition Method	Occurrence Definition	Climate Scenario	Reference Location	Parameter source	Direction Confidence	Magnitude Confidence
Wind															
River flooding															
Ice Accretion													Earth System Sciences 19, 857-872. Values estimated from inspection of Figures 4 and 5.		
Wildfire	wildfire risk	climatic moisture deficit	392 mm (1981-2010)	3	480 mm (2041-2070)	4	521 mm (2071-2100)	5	A	Annual	RCP8.5 (CanESM2)	Clean River	ClimateWNA, assessed at Clean River location.	High	High

Step 3 - Assessment

Separate Risk Assessment Worksheet for each Asset: Stormwater, Water and Wastewater, Buildings and Facilities, Electricity, Roads, Fleet, and Transit and Environment. (Electricity Shown Below))

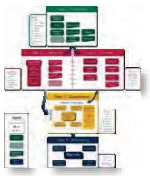


Step 4 - Reporting

Climate Hazard / Parameter	Potential Adaptation Measures	Stormwater	Water and Wastewater	Buildings and Facilities	Electric Utilities	Roads, Fleet, Transit	Environment
Extreme High Summer Temperature/ Drought	Develop a city-wide heat wave emergency preparedness and response plan		x	x	x	x	x
	Develop safety policy for staff when working under this extreme weather condition	x	x	x	x	x	x
	Replace electrical and control equipment to account for extreme heat.		x	x	x	x	
	Provide sufficient circulation to the stormwater ponds to prevent stagnation.	x					x
	Continue to implement water conservation and water use efficiency education and awareness programs.		x	x			x
	Promote and provide incentives for water conservation in urban agriculture, including grey water recycling and water retention and storage technologies.		x	x			x
	Evaluate treatment effectiveness and its responses to high temperatures.		x				
	Investigate new asphalt mixes to reduce the heat island effect.					x	
	Conduct building envelop/energy audit to identify issues with ventilation and cooling.		x	x	x		
	Develop species inventory and identify species that are susceptible to and tolerant of this extreme heat and drought.			x			x
	Introduce drought resistant planting to help stabilize road and trail embankments.			x		x	x

Example Project 3 Portfolio Asset Assessment

Clean River Coop Production and Wearhouse Facilities



The Clean River Coop owns and operates product warehouse distribution centers across the Prairies, Ontario and Quebec. These facilities include administration buildings, warehouse storage, equipment and trucking maintence and repair facilities. Each site is on the outskirts of the local city and has access to water, wastewater solid waste municipal services. Unique to several of the locations are tree farms where ornamental trees are grown and processed for local distribution.

As part of the Coop's goals of sustainable business practices, the Coop conducted a PIEVC High Level Screening Portfolio Assessment to identify high risks to the Coop's infrastructure resulting from climate change. The goal was to identify climate risks and adaptive measures to consider in future decisions around capital planning and their asset management program. The assessment was completed with the assistance of an engineering consultant specializing in assessments. A series of workshops were completed at each facility with local management and operations staff.

Step 1 - Overview

Assessment Objectives

Objective: Complete a climate risk and vulnerability assessment on the Clean River Coop Production and Wearhouse facilities to identify climate risks and adaptive measures to consider in future decisions around capital planning and their asset management program. This project was to coincide with a new asset management system being onboarded for a third of the Coop's facilities.

Scope

PIEVC HLSG assessment: Production and Wearhouse facilities – Selected 2 of the 8 Prairie Locations, 3 of the 17 Ontario Locations and 2 of the 6 Quebec locations plus one future location site. All locations were in the process of updating Asset Management Plans or in planning. Assessment Horizon. Current, 2050, 2080 based on with lifecycle Assets of ~ 30 to 60 years.

Work Plan

Schedule: Project to be completed over 12 month period with a meeting, orientation session and risk workshop for each location thought the summer months.

Assessment Team: **Consultant:** Risk Assessment Specialist, Climate Specialist, **Coop Staff:** Technical / Engineering, Operation & Maintenance, Management, Corporate Sustainability Officer, Assistant CFO. **Stakeholders:** Local Municipality and First Nation Representatives.

Step 2 - Elements

Locations (Assets)	
1	Prairies L-306
2	Prairies L-204
3	Ontario L-343
4	Ontario L-365
5	Ontario L-416
6	Quebec L-581
7	Quebec L-450
8	*Quebec L-514*

Production and Wearhouse Facilities (Typical Elements)
Site
Roads and Parking
Landscaped Areas
Site Drainage
Tree Farm
Buidlings
Management
Structure / Envelope
Mecanical HVAC
Electrical and Utilites
Wearhouse
Structure / Envelope
Mecanical HVAC
Electrical and Utilites
Equipment
Staff
Management
Opaertions Staff
Public

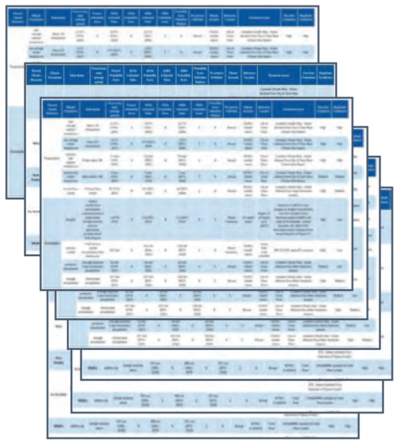
Step 2 - Climate

1976-2005, 2021-2050, 2051-2080.
Source: Climate Data Canada

Locations (Assets)	
1	Prairies L-306
2	Prairies L-204
3	Ontario L-343
4	Ontario L-365
5	Ontario L-416
6	Quebec L-581
7	Quebec L-450
8	*Quebec L-514*

Temperature
High Average Summer Temperature
Low Average Winter Temperature
Extreme High Summer Temperature
Extreme Low Winter Temperature
Freeze/Thaw Events
Precipitation
Drought
Extreme Rainfall
Persistent Precipitation
Extreme Snowfall
Hail Days
Average Precipitation
Maximum Wind Gust
River Flooding
Freezing Rain
Wildfire
Tornado

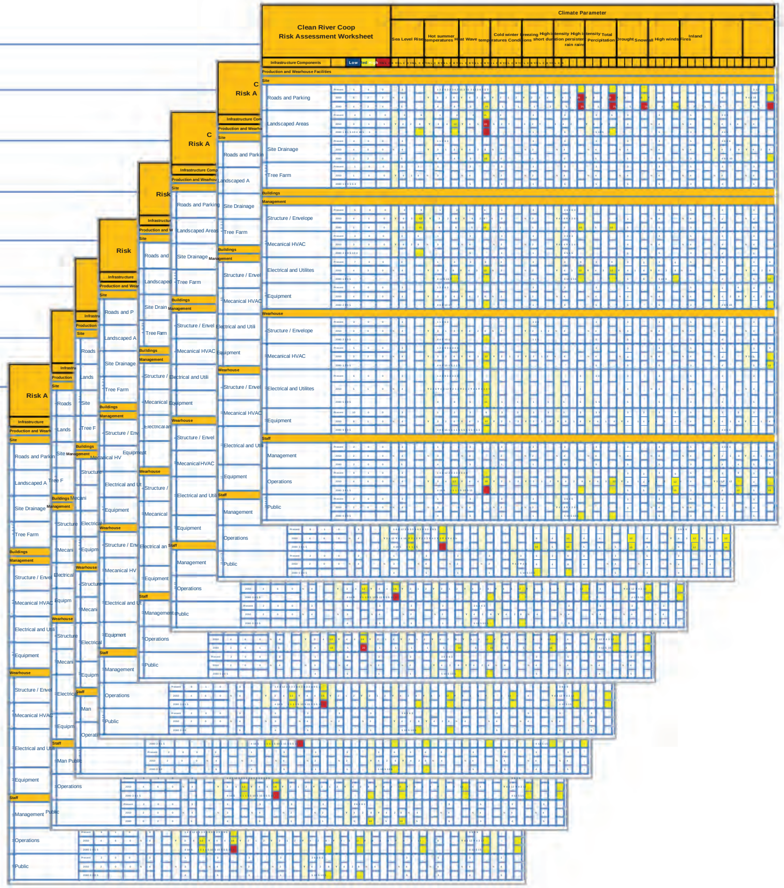
Climate Report per Location (8 in total)



Step 3 - Assessment

Separate Risk Assessment Worksheet for each Asset:

Locations (Assets)	
1	Prairies L-306
2	Prairies L-204
3	Ontario L-343
4	Ontario L-365
5	Ontario L-416
6	Quebec L-581
7	Quebec L-450
8	*Quebec L-514 (Future)*



Step 4 - Reporting

Risk Summary

	Locations	**Site**	**Buildings**	**Staff**
1	Prairies L-306			
2	Prairies L-204			
3	Ontario L-343			
4	Ontario L-365			
5	Ontario L-416			
6	Quebec L-581			
7	Quebec L-450			
8	*Quebec L-514 (Future)*			

Appendix - Supporting Documents

Examples of Assets, Infrastructure Categories, Elements and Climate Parameters
(Starting point in an assessment)

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Roadway	Roadway prism	Asphalt	Temperature	Extreme Heat Extreme Cold Freeze-Thaw Cycles Heat Waves
		Road base		
		Shoulders		
		Road marking		
		Ditches		
		Embankment/ slopes	Precipitation	Long Duration Rain Short Duration High Intensity Rain Freezing Rain Heavy Snowfall
	Surface	Curbs		
		Protection works (e.g., riprap)		
		Bridges		
		Bridge approach guardrail	Wind	Wind Gusts
		Road signage - all types	Other	Tornadoes
		Road signage - sheeting		
		Street luminaires/poles		
		Traffic light		
	Underground	Drainage appliances (e.g., outfall, sewer, MHs)		
		Catch basins		
		Grates		
		Culverts		
	Other	Personnel (O&M staff)		
		Third party utilities (above ground)		
		Third party utilities (below ground)		

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Airport 	Airport Terminal Building - Structural	Envelope	Temperature	Extreme Heat Extreme Cold Freeze-Thaw Cycles Rapid Freeze Heat Waves
		Roofing		
		Foundation		
		Plumbing system (Roof drains, piping distribution, etc.)		
		Emergency route		
	Airport Terminal Building - Mechanical	Boilers/Heating Systems	Precipitation	Long Duration Rain Short Duration High Intensity Rain Freezing Rain Heavy Snow
		Chillers/Cooling Systems		
		HVAC components		
		Building controls and automation systems		
		Food and housekeeping services (e.g. Refrigerators, water cooler, filling stations)	Wind	Sustained Winds Wind Gusts
		Fire protection		
	Airport Terminal Building - Electrical and Emergency Systems	Fire Alarm System	Other	Lightning Fog Tornadoes
		Security Systems (cameras, CCTV, etc.)		
		Electrical distribution		
		Lighting Systems		
		Generator Systems		
		Communications		
	Transportation	Runway		
		Ramps and apron		
		Taxiways		
		Drainage Appliances		
		Parking and access road		
		Lighting systems		
	Airport - Utilities	Water supply system		
		Sanitary Sewer system		
		Storm Drainage system		
		Electrical Power Supply and Distribution		
	Other	Air Traffic Control Tower and beacons		
		Field Electrical Centre		
		Fuel Storage Facilities		
		Aircraft Sewage Disposal		
		Personnel (Public, O&M staff)		

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Power Plant (Hydroelectric) 	Administrative / Operational / Substation Buildings	Structural Components	Temperature	Extreme Heat Extreme Cold Freeze thaw Cycles Water Temperatures
	Substations	Station Load Break Switch		
		Station Capacitor Voltage Transformers		
		Station Circuit Breakers		
		Station Power Transformers	Precipitation	Long Duration Rain Short Duration High Intensity Rain Snowpack Freezing Rain Timing of freshet Flood
		Station Metering		
		Station P&C Cabinets and Batteries		
		Station Grounding and Ground Grid		
		Station Miscellaneous Equipment		
	Power Distribution - Overhead	Distribution Lines	Wind	Wind Gusts Sustained winds
		Poles		
		Overhead Transformer	Other	Snow Water Equivalent Snow Depth
		Overhead Load Breaker Switch		
		Ground Connection		
		Surge Arrestors		
		Fused Cut Out		
	Power Distribution - Underground (if any)	Civil Structures		
		Underground Cables		
		Underground Primary Switchgear		
		Underground Transformers		
	Service and Personnel	Service Vehicles		
		Service Equipment		
		Personnel (O&M staff)		
	Other	Grid and Residential Metering		
		Telecommunications		
		Fuel Supply		
		Emergency Resources		

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Bridge 	Substructure	Foundations and piers	Temperature	Same as Road, with addition of Rapid Temperature Change
		Abutments		
	Superstructure	Bearings	Precipitation	Same as Road, with addition of Blowing Snow
	Deck	Deck		
		Wearing surface	Wind	Same as Road, with addition of Sustained wind Design Wind Gust (structure type dependent)
		Expansion joints		
		Barrier and guard rails	Other	Same as Road, with addition of Rain on Snow Lightning Fog
		Gutter and catch basins		
		Downspouts		
	Other	Public		
		O&M staff		

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Ports 	Port Infrastructure	Pier/ water break	Temperature	Same as Bridge and Road, with additions of Water Temperatures
		Berth calls		
		Equipment for cargo movement		
		Storage yard	Precipitation	Same as bridge and Road,
	Personnel	Port Management		
		Operation	Wind	Wind Gusts
		Maintenance	Other	Local Sea Level Rise Storm Surge Design Wave Heights Erosion

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Water Supply System 	Water Supply Intake	Intake structure	Temperature	Extreme Heat Extreme Cold Heat Wave Cold Snap
		Raw Water Pump Stations		
	Water Treatment Plant Building - Structural	Envelope		
		Roofing		
		Foundation	Precipitation	Long Duration Rain Short Duration High Intensity Rain Drought
	Water Treatment Plant Building - Mechanical	Boilers/Heating Systems		
		Chillers/Cooling Systems		
		HVAC controls and automation systems	Winds	Wind Gusts
		Air handling/ ventilation systems	Other	Tornadoes Coastal Parameters (e.g. sea level rise, if near salt water source)
	Water Treatment Plant Building - Electrical	Fire alarm and protection		
		Lighting systems		
		Building controls and automation systems		
		Emergency backup power		
		Communication Systems		
	Water Treatment Plant Building - Treatment Infrastructure	Process equipment		
	Water Treatment Plant Building - Site Services	Stormwater drainage system		
		Power supply and distribution		
	Storage and Distribution	Storage tank/ reservoir		
		Pump stations		
		Feeder mains		
	Other	Personnel (O&M staff)		
		Site access - Parking, access lanes, etc.		
		Lighting Pole, Signage		

Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Wastewater Treatment Plant 	WWTP Building -Structural	Envelope	Temperature	Extreme Heat Extreme Cold Freeze-Thaw Heat Wave Cold Snap Freezing Degree Days
		Roofing		
		Foundation		
	WWTP Building - Mechanical	Boilers/Heating Systems		
		Chillers/Cooling Systems		
		HVAC controls and automation systems		
		Air handling/ ventilation systems	Precipitation	Long Duration Rain Short Duration High Intensity Rain
	WWTP Building - Electrical, Instrumentation and Control Systems	Fire alarm and protection		
		Lighting systems		
		Building controls and automation systems	Winds	Wind Gusts
		Emergency backup power		
		Communication Systems	Other	Tornadoes
	Treatment Infrastructure	Process equipment (Activated sludge, Aeration tank, filtration system)		
	WWTP - Site Services	Stormwater drainage system		
		Power supply and distribution		
		Site service water and potable water supply		
	Other	Parking, access lanes, etc.		
		Lighting Pole, Signage		
		Personnel (O&M staff)		

Appendix - Supporting Documents

Example Climate Report

Climate Parameter (P)	Climate Hazard (H)	Indicator (I)	Present (1981-2010) Estimated Value	Baseline Likelihood Score (L)	2050s (2041-2070) Estimated Value	2050s Likelihood Score (L)	2080s (2071-2100) Estimated Value	2080s Likelihood Score (L)	Probability Score Methodology	Occurrence Definition	Climate Scenario	Parameter Source	Direction / Magnitude Confidence
Temperature	Extreme Heat	Days with Tmax > 35°C	0.2	3	1.6	4	6.5	5	Middle Baseline	Days per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/High
	Extreme Cold	Days with Tmin < -30°C	2.3	3	0.5	2	0.1	1	Middle Baseline	Days per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Decreasing/High
	Freeze Thaw Cycles	Annual Frequency	59.8	3	49.9	3	43	3	Middle Baseline	Cycles per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Decreasing/High
Precipitation	Annual Precipitation	Average Annual Precip	410	3	450	3	550	4	Middle Baseline	Total Precip (mm)	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/Moderate
	Extreme Rainfall	Occurrence of 50mm rainfall in 24 hours	0.02	3	0.04	4	0.05	4	Middle Baseline	Frequency per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/Low-to-Moderate
	Drought	Length of Dry Spells	5.2	3	8.8	4	10.2	5	Middle Baseline	Consecutive days per year	RCP 8.5	Climate Data.ca Observed Data and Projections; Additional Calculations	Increasing/Moderate
Wind	Wind Gusts	Frequency of Wind Gusts > 90 km/hr	2.3	3	Likely increasing, up to 50%	3	Likely increasing, up > 50%	4	Middle Baseline	Frequency per year	RCP 8.5	Climate Data.ca Observed Data from Station; Literature and Research to support projected changes	Likely Increasing/Low
	Tornadoes	Occurrence of EF1 or stronger tornado	0.02	3	0.02	3	0.02	3	Middle Baseline	Frequency per year	RCP 8.5	ECCC Tornado Database; Literature and Research to support possible changes.	Steady or Possibly Increasing/Very Low

Climate Report Template

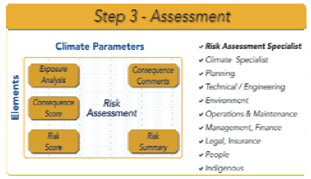
Climate Parameter (P)	Index Description	Present (1971-2000) Estimated Value	Baseline Likelihood Score (L)	2050s (2041-2070) Estimated Value	2050s Likelihood Score (L)	2080s (2071-2100) Estimated Value	2080s Likelihood Score (L)	Probability Score Methodology	Occurrence Definition	Climate Scenario	Reference Location	Direction / Maginitute Confidence	Parameter source

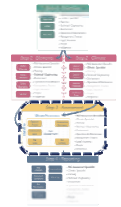
Appendix - Supporting Documents

Risk Assessment Template

Risk Assessment Worksheet

Consequence Score (C)
- 1 - Very Low
- 2 - Low
- 3 - Moderate
- 4 - High
- 5 - Very High





Climate Parameters (P)					
Example *Mean Temperature (Deg. C.)*					

Climate Projections		P1	L	P2	L	P3	L	P4	L	P5	L	P6	L
	Present	2,9	3										
	2050	5,2	3										
	2080	7,5	4										

Elements (E)			Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Summary	Low	Med	High	Consequence Comments
1	**Example**	Present		3		15		0		0		0		0		0		0		0		0		0		0	Present	0	1	0	
		2050	Y	3	5	15		0		0		0		0		0		0		0		0		0		0	2050	0	1	0	
		2080		4		20		0		0		0		0		0		0		0		0		0		0	2080	0	0	1	
2		Present		3		0		0		0		0		0		0		0		0		0		0		0	Present	0	0	0	
		2050		3		0		0		0		0		0		0		0		0		0		0		0	2050	0	0	0	
		2080		4		0		0		0		0		0		0		0		0		0		0		0	2080	0	0	0	
3		Present		3		0		0		0		0		0		0		0		0		0		0		0	Present	0	0	0	
		2050		3		0		0		0		0		0		0		0		0		0		0		0	2050	0	0	0	
		2080		4		0		0		0		0		0		0		0		0		0		0		0	2080	0	0	0	
4		Present		3		0		0		0		0		0		0		0		0		0		0		0	Present	0	0	0	
		2050		3		0		0		0		0		0		0		0		0		0		0		0	2050	0	0	0	
		2080		4		0		0		0		0		0		0		0		0		0		0		0	2080	0	0	0	
5		Present		3		0		0		0		0		0		0		0		0		0		0		0	Present	0	0	0	
		2050		3		0		0		0		0		0		0		0		0		0		0		0	2050	0	0	0	
		2080		4		0		0		0		0		0		0		0		0		0		0		0	2080	0	0	0	
8		Present		3		0		0		0		0		0		0		0		0		0		0		0	Present	0	0	0	
		2050		3		0		0		0		0		0		0		0		0		0		0		0	2050	0	0	0	
		2080		4		0		0		0		0		0		0		0		0		0		0		0	2080	0	0	0	

Risk Assessment:
1. Assess interaction (E and P) by performing a Exposure Analysis (Yes/No)
2. Assess consequence: For each (Yes) interaction assess a Consequence, Score (C)
3. Record why a score was chosen (Consequence Comments)
4. Calculate the Risk (R) for each interaction (R=C x L)
5. Review Risk Summary

	Low	Med	High	
Present	0	1	0	Risk Summary
2050	0	1	0	
2080	0	0	1	

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