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# Infrastructure Climate Risk Assessment
## How to conduct an assessment featuring PIEVC

**Jeff O'Driscoll,** P.Eng., IRP
**Division Manager, Infrastructure**
**February 2023**

ENGINEERS GEOSCIENTISTS MANITOBA

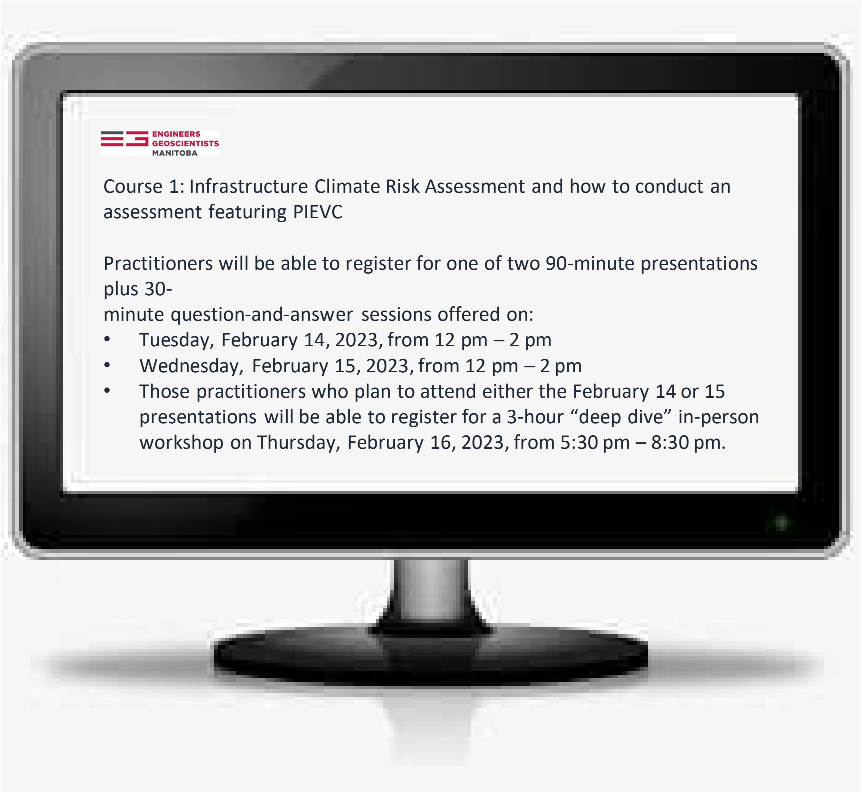
MANITOBA CLIMATE RESILIENCE TRAINING

# Interaction


- The course is being recorded - your participation confirms your agreement
- Cameras and Microphones are off
- Polls to receive your feedback
- Chat is open
  - During Presentation and Q&A
  - Comments are welcome and will be monitored
  - Please send comments to Everyone not the presenter
- Technical issues, chat issue to EngGeoMB
- Presentation slides will be made available
- Follow-up with survey and details of the presentation

# COURSE

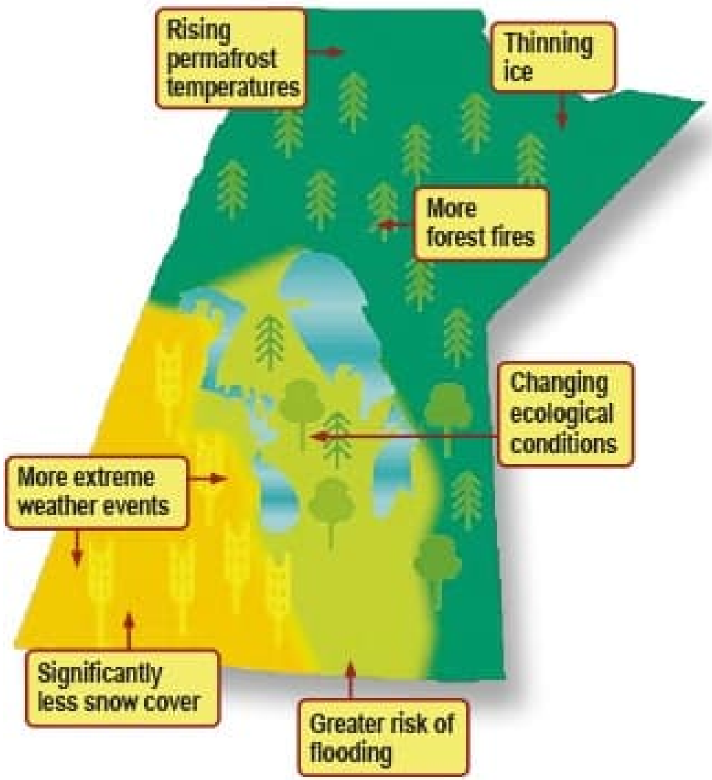

- Climate Change Resilience Assessment
- Example Project
- Question and Answer Session



# Course


- Course will walk you through a climate change risk assessment (CCRA), using the PIEVC HLSG process
- Demonstrate how climate data is obtained and used in assessing and managing risk, informing design parameters/criteria and communicating climate impacts.

# Overview




- Manitoba's Climate is Changing
  - Warmer and wetter winters
  - Longer, warmer and drier summers.
  - Greater variability in precipitation
  - Greater frequency and intensity of
    - Heat waves and cold snaps
    - Droughts and floods
    - Intense storms

# Overview



- Impacts
  - Flood and drought risks will be higher
  - Warmer winters will degrade ice roads making it harder to transport supplies to communities.
  - Extreme weather events will impact insurance costs and government spending on disaster relief.

# Poll

Poll: Which of the following climate impacts are of the most relevance to your work area? You can choose more than one.

- a) Extreme heat
- b) Extreme cold
- c) Extreme rainfall
- d) Heavy snowfall
- e) Ice Storms
- g) Drought
- h) Flooding
- i) Wildfires
- j) Heavy Winds (> 70 km/hr)

# Climate Change Risk Assessment


pievc.ca

- PIEVC Process
  - Systematic process to assess historic climate and project the nature, consequence and likelihood of future climate changes and events on infrastructure to inform planning, design, operation and management.
- PIEVC
  - Public Infrastructure Engineering Vulnerability Committee (Engineers Canada)

# Climate Change Risk Assessment


- PIEVC Program (pievc.ca)
  - Ownership and control of the PIEVC Program 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.

pievc.ca

PIEVC Products

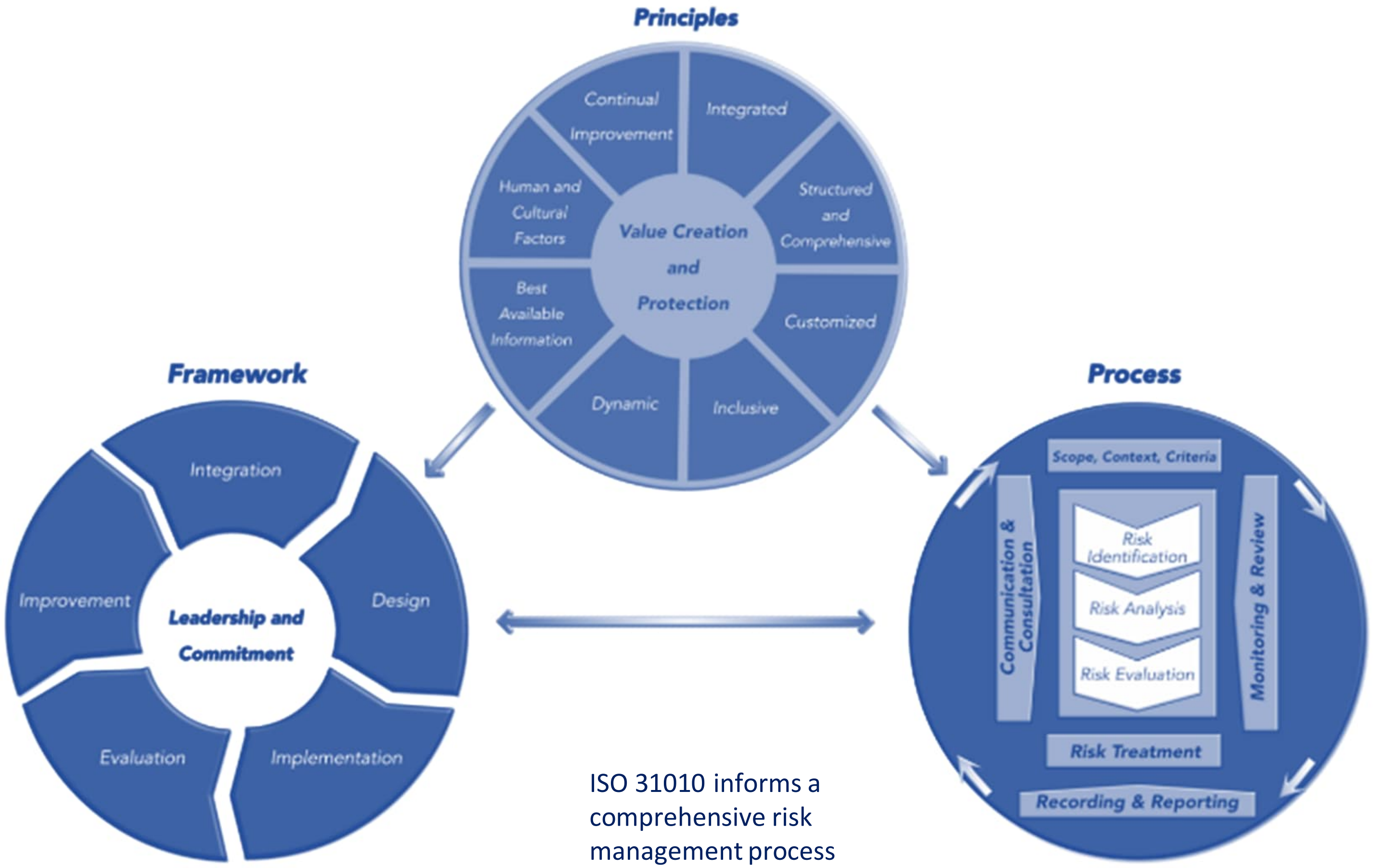
- PIEVC Protocol
- **PIEVC High Level Screening Guide**
- PIEVC Large Portfolio Assessment Manual
- PIEVC Green
- Infrastructure Resilience Professional(IRP) Training

# Why Assess Risk?

- To deal with uncertainties of future climate
- To deal with risks to physical infrastructure and infrastructure service and disruptions
- To protect people, property and environment
- To consider legal, financial and lifecycle and management
- To prioritize actions to adapt to increasing challenges and impacts
- To change the way we design, build and manage infrastructure and be more resilient

# When to Assess Risk?

- Full lifecycle
  - Planning
  - Design
  - Operation
  - Upgrade




ISO 31010 informs a comprehensive risk management process

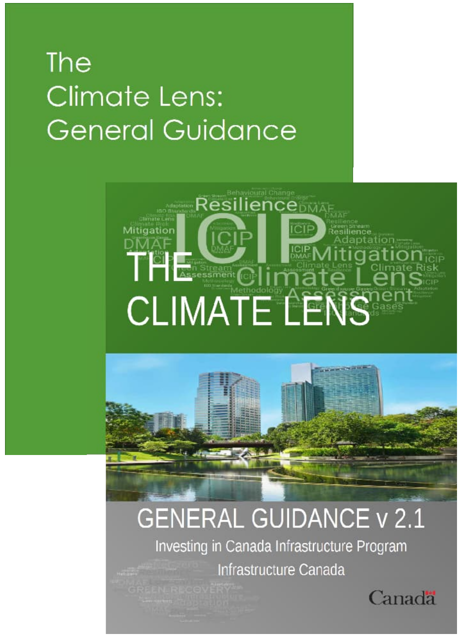
# When to Assess Risk?

- Full lifecycle
  - Planning
  - Design
  - Operation
  - Upgrade

| | Expected Lifecycle |
|---|---|
| Dams/ Water Supply | Base system 50-100 yrs<br>Refurbishment 20-30 yrs<br>Reconstruction 50 yrs |
| Storm/Sanitary Sewer | Base system 100 yrs<br>Major upgrade 50 yrs<br>Components 25 – 50 yrs |
| Roads & Bridges | Road surface 10 - 20 yrs<br>Bridges 50 - 100 yrs<br>Maintenance annually<br>Resurface concrete 20-25 yrs<br>Reconstruction 50-100 yrs |
| Houses/ Buildings | Retrofit/alterations 15-20 yrs<br>Demolition 50-100 yrs |

# Applications

- Infrastructure Canada's **Climate Lens**
- 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.

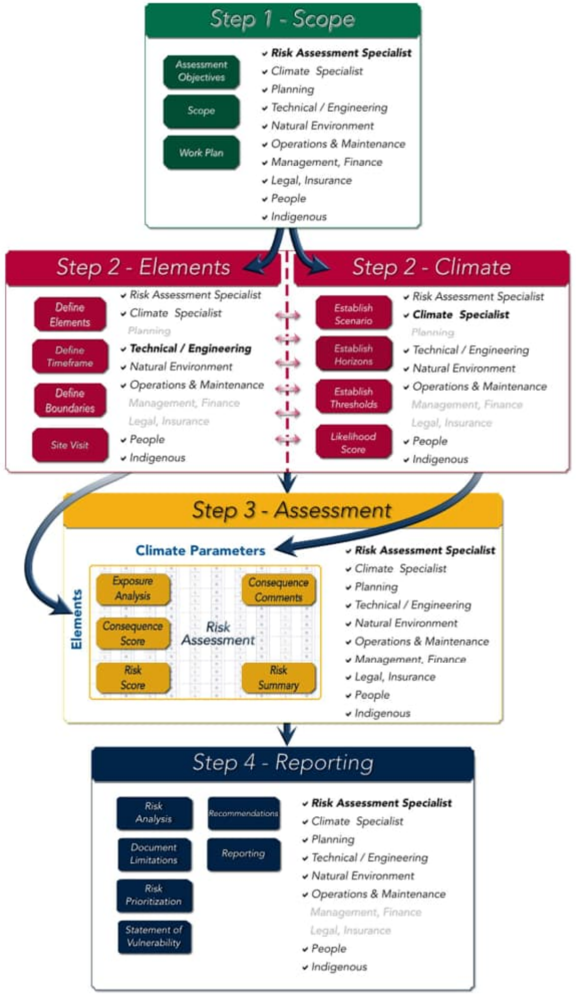


# Applications

- 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**.

# PIEVC Process

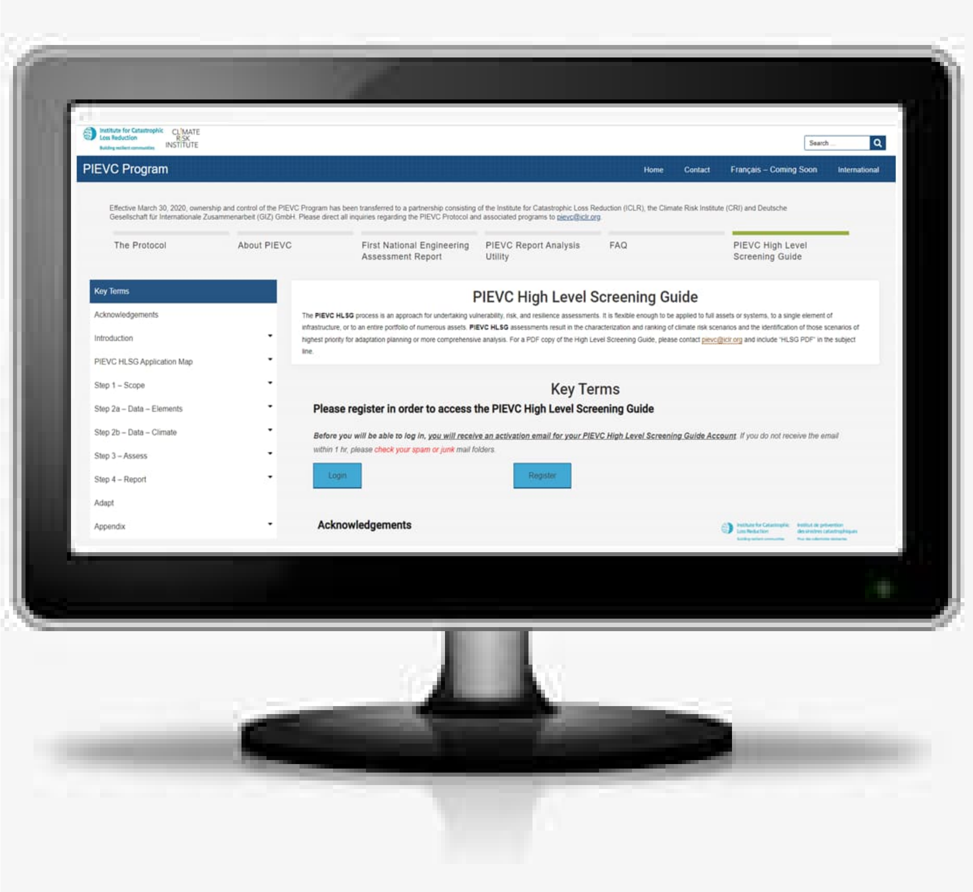




# PIEVC PROCESS

- The **PIEVC High Level Screening Guide (HLSG)** was developed to provide a screening level assessment approach to climate change resilience assessments.

pievc.ca




https://pievc.ca/pievc-high-level-screening-guide/

# PIEVC HLSG

- The HLSG was developed by a team of experienced practitioners and stakeholders


## Acknowledgements

This guide has been prepared based on many years of professional experience using the PIEVC Protocol and other climate and infrastructure vulnerability and risk assessment methods. Writing Team members include:

- Jeff O'Driscoll, Associated Engineering
- Joel Nodelman, Nodelcorp
- Joan Nodelman, Nodelcorp
- Norman Shippee, Stantec Consulting
- Erik Sparling, Climate Risk Institute
- Glenn Milner, Climate Risk Institute
- Kirsten MacMillan, Climate Risk Institute

We also acknowledge the time and efforts of the Advisory Committee. The knowledge and experience of these individuals have helped shape a guide that is accessible, defensible, and applicable to a broad range of infrastructure assets, systems, and portfolios. Advisory Committee members include:

- Benjamin Hodick, Deutsche Gesellschaft für Internationale Zusammenarbeit
- Beth Lavender, Treasury Board of Canada Secretariat
- Dan Sandink, Institute for Catastrophic Loss Reduction
- David Lapp, Institute for Catastrophic Loss Reduction
- Derek Gray, AECOM
- Dustin Carey, Federation of Canadian Municipalities
- Elise Pare, WSP
- Elmer Lickers, Ontario First Nations Technical Services Corporation
- Isabelle Charron, Ouranos
- Kate Miller, Cowichan Valley Regional District
- Laure Gerard, Public Services and Procurement Canada
- Pamela Kertland, Natural Resources Canada
- Peter Nimmrichter, Wood
- Quentin Chiotti, Matrix Solutions Inc.
- Sincy Modayil, City of Edmonton
- Tom Duncan, Crown-Indigenous Relations and Northern Affairs Canada
- Trevor Murdock, Canadian Centre for Climate Services

The following individuals also provided valuable input to the guide:

- Darrel Danyluk, World Federation of Engineering Organizations
- Fiona Hill, National Research Council of Canada
- Marla Desat, Standards Council of Canada
- Marianne Armstrong, National Research Council of Canada
- Nathalie Bleau, Ouranos


Institute for Catastrophic Loss Reduction — Building resilient communities
Institut de prévention des sinistres catastrophiques — Pour des collectivités résistantes

CLIMATE RISK INSTITUTE

Associated Engineering

NODELCorp

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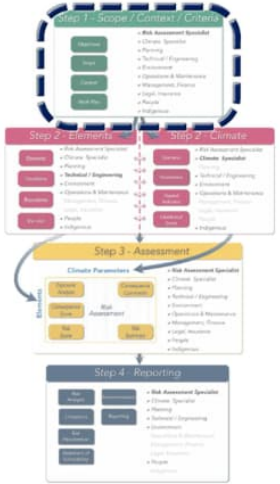
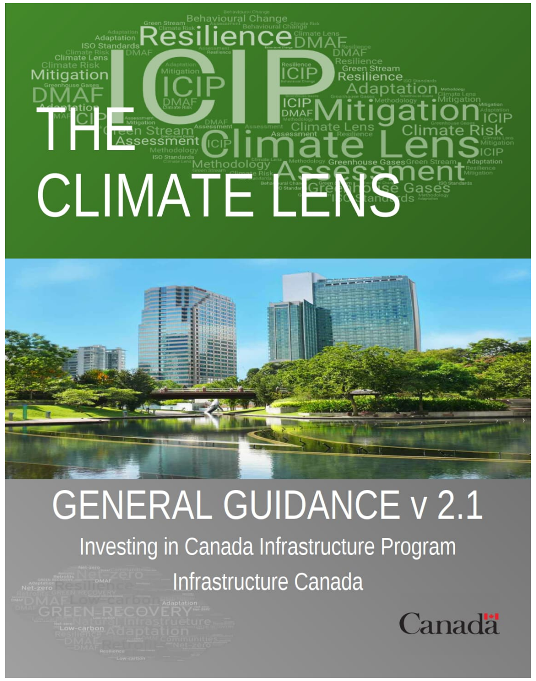
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

## 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 **PIEVC HLSG** can be found at **www.pievc.ca**.

# PIEVC HLSG – Step 1

# PIEVC HLSG – Step 1


- **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***

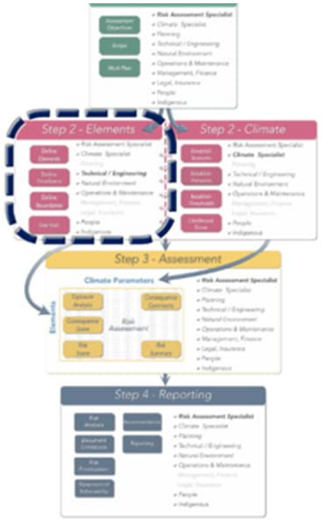
*The **infrastructure Resilience Professional (IRP) Training Program** has been designed to help infrastructure practitioners strengthen the knowledge and competencies they require to advance more climate-resilient approaches for the planning, design, and management of infrastructure.*

***https://climateriskinstitute.ca/irp-page/***

# PIEVC HLSG – STEP 1

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

# PIEVC HLSG – Step 2

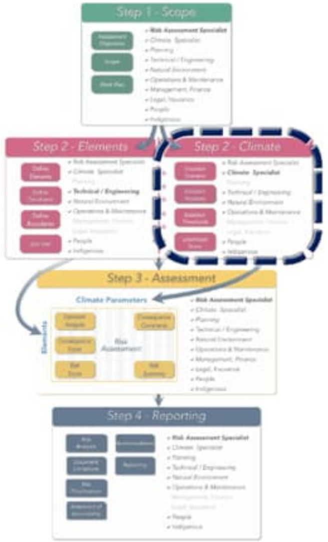

| Asset Category | Example |
|---|---|
| **Built Infrastructure** | ▪ Buildings, Transportation Infrastructure, Energy and Electrical Infrastructure, Water Resources and Drainage, Water Supply, Treatment, Communication Infrastructure, Infrastructure, etc. |
| **Natural Environment** | ▪ Green Infrastructure, Soils, Tree Canopy, Bioswales, etc.<br>▪ Natural Systems<br>▪ 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. |

# PIEVC HLSG – Step 2

| Asset | Elements | Sub Elements | Parameters | Hazards for Consideration |
|---|---|---|---|---|
| Roadway | Roadway prism | Asphalt | Temperature | Extreme Heat<br>Extreme Cold<br>Freeze-Thaw Cycles<br>Heat Waves |
| | | Road base | | |
| | | Shoulders | | |
| | | Road marking | | |
| | | Ditches | | |
| | | Embankment/ slopes | Precipitation | Long Duration Rain<br>Short Duration<br>High Intensity Rain<br>Freezing Rain<br>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<br>Extreme Cold<br>Freeze-Thaw Cycles<br>Rapid Freeze<br>Heat Waves |
| | | Roofing | | |
| | | Foundation | | |
| | | Plumbing system (Roof drains, piping distribution, etc.) | | |
| | | Emergency route | | |
| | Airport Terminal Building - Mechanical | Boilers/Heating Systems | Precipitation | Long Duration Rain<br>Short Duration<br>High Intensity Rain<br>Freezing Rain<br>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<br>Wind Gusts |
| | | Fire protection | | |
| | Airport Terminal Building - Electrical and Emergency Systems | Fire Alarm System | Other | Lightning<br>Fog<br>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) | | |

# PIEVC HLSG – Step 2


### 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.

Other Hazards:

- Seismic

# PIEVC HLSG – STEP 2

| 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.*

# PIEVC HLSG – Step 2

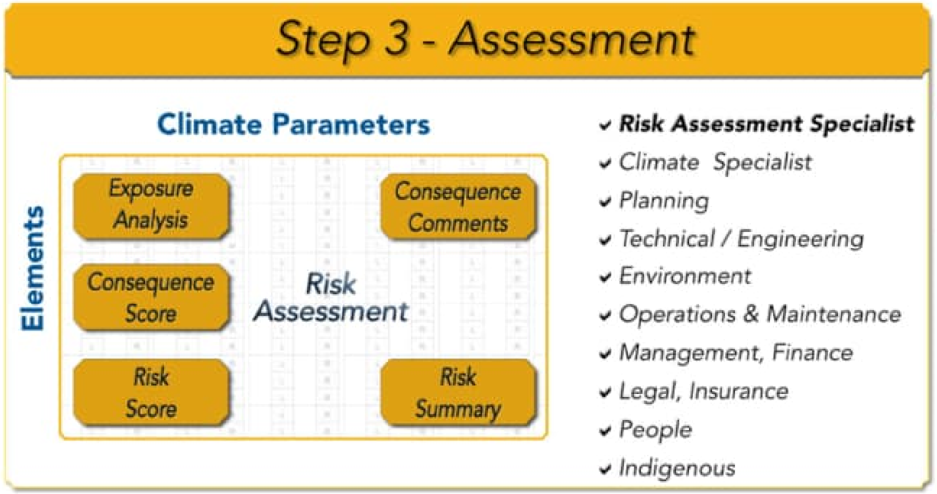
| Likelihood Score (L) | Middle Baseline Approach - Establish Base | Method | Suggested Rational |
|---|---|---|---|
| 1 | ▲ | Likely to occur less frequently than current climate | 50 – 100% reduction in frequency or intensity with reference to Baseline Mean |
| 2 | | | 10 – 50% reduction in frequency 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 |

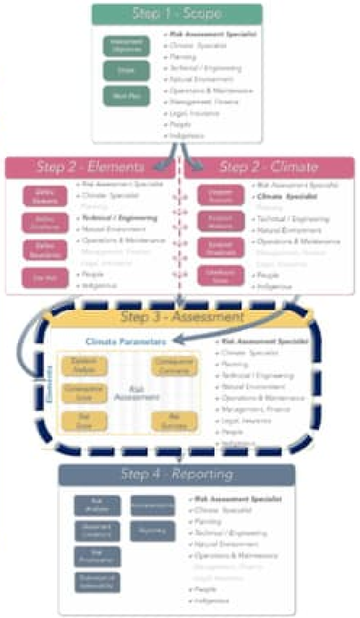
***For the PIEVC HLSG**, a simplified middle baseline likelihood scoring approach is proposed. For more detailed assessment including in the PIEVC Protocol, other scales and likelihood score assigning may be used.*

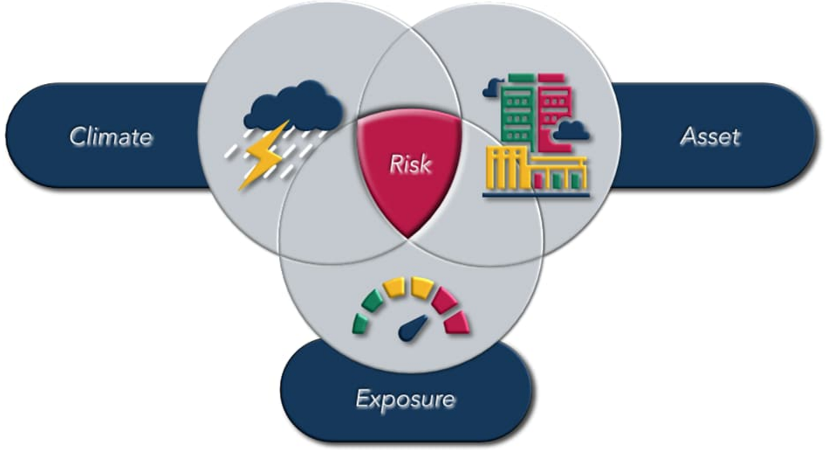
# PIEVC HLSG – Step 2

| 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 | 6.8 | 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 | Occurence 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 |

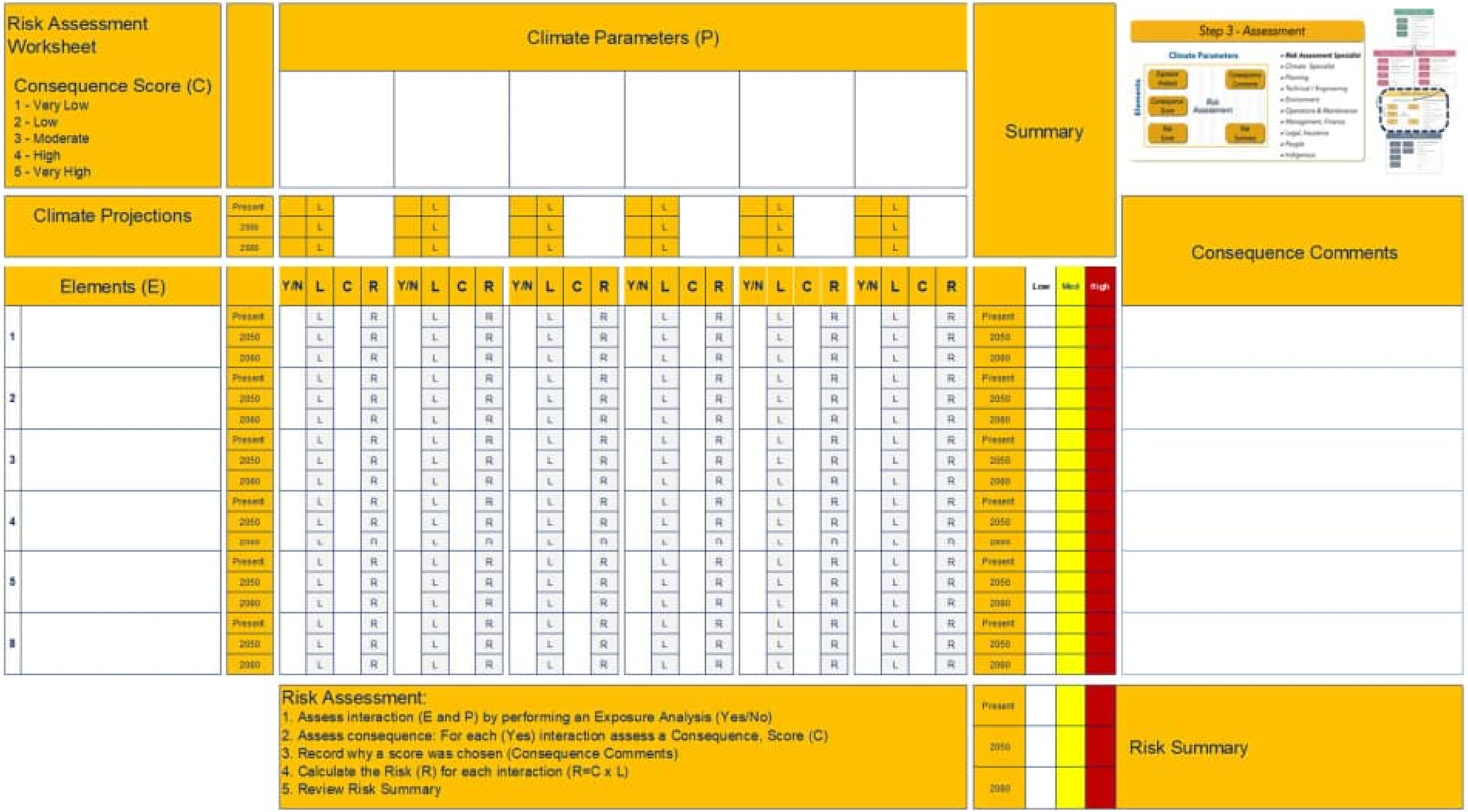
# PIEVC HLSG – Step 3



# PIEVC HLSG – Step 3



# PIEVC HLSG – Step 3

## 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**

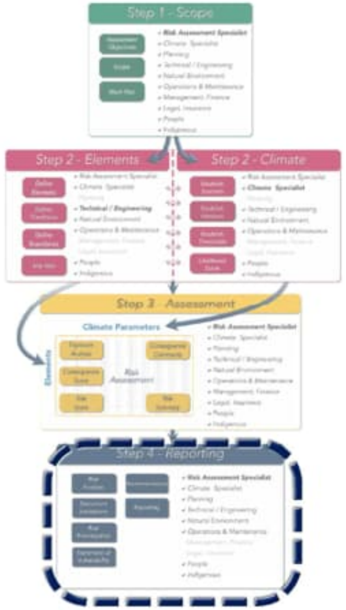
## Summarize the Risks

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 | (yellow) | Medium Risk | Risk that may require further action |
| 17 - 25 | (red) | High Risk | Risks that require action |

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

# PIEVC HLSG – Step 4


## 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.

# PIEVC HLSG – STEP 4

## 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.
  - Further comprehensive risk assessment.
  - Further engineering analysis or design changes.
    - Provide preliminary design criteria that may address the risk to guide engineering team.
  - Risk avoidance strategies.
    - Consider stopping activities in high-risk areas.

## 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.

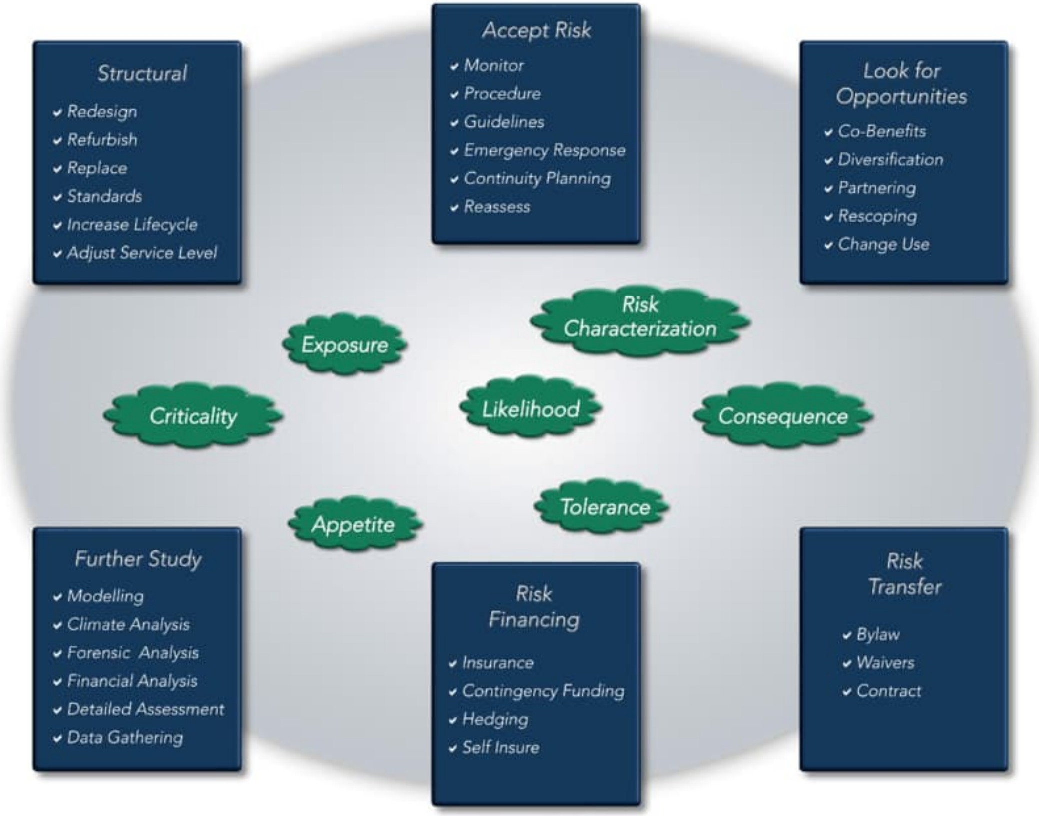
# PIEVC HLSG – STEP 4

## 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.

# PIEVC HLSG – NEXT STEP….


## Adapt



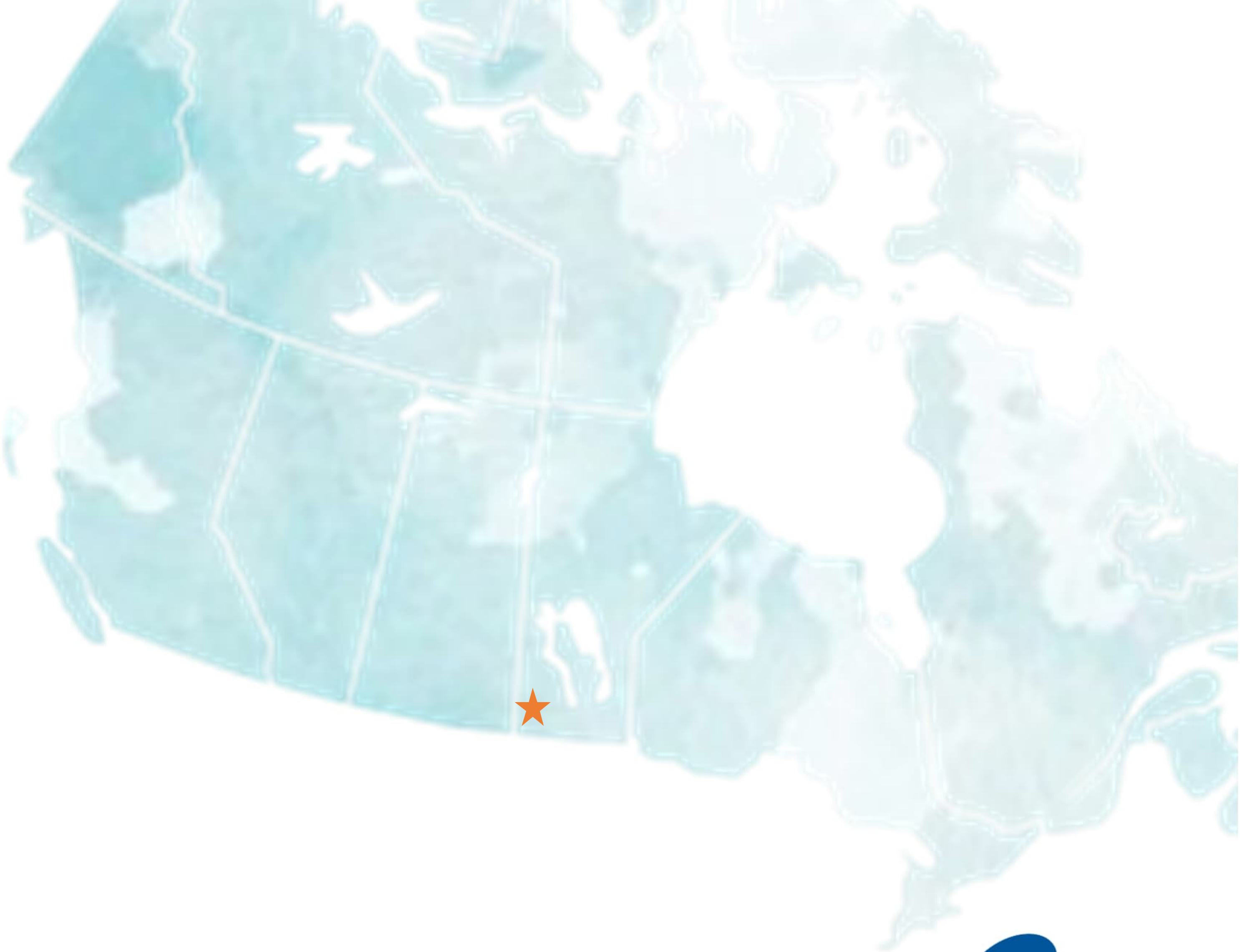

***Next Steps after a screening assessment*:**

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

# Example Project

- Highway 10 near the Town of Minnedosa

Note: This is not an actual assessment. The example project and location is used solely to demonstrate the process



ENGINEERS GEOSCIENTISTS MANITOBA

Associated STRATEGIC ADVISORY SERVICES

# Example Project

- Highway 10 near the Town of Minnedosa

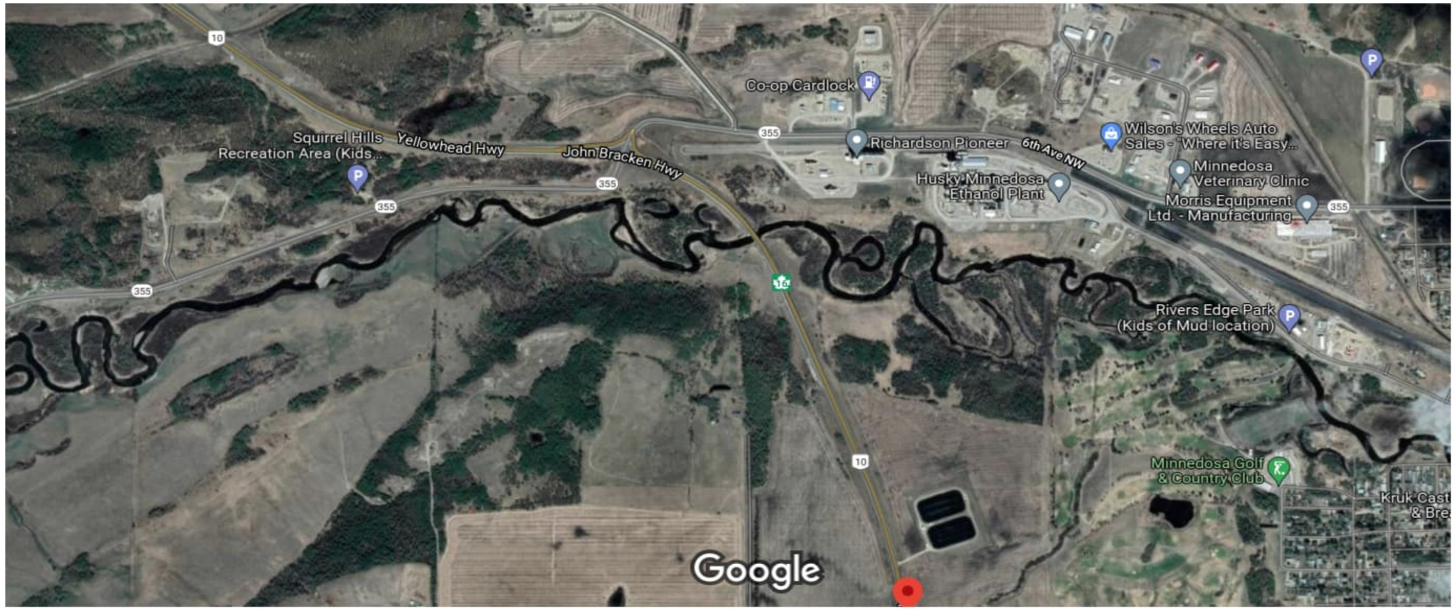
# Example Project

- Highway 10 near the Town of Minnedosa

Google Maps

MB-10

Highway 10



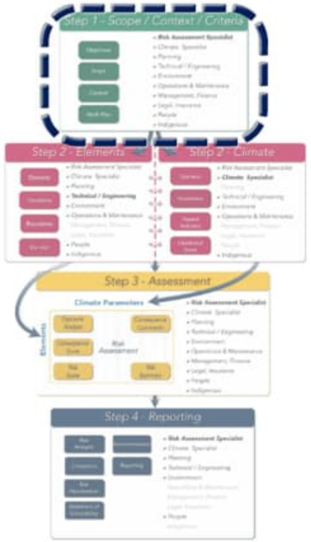

Imagery ©2021 CNES / Airbus, Maxar Technologies, Map data ©2021 200 m

# EXAMPLE PROJECT



# Example Project


# Defining the Scope - Step 1


- Scope / Context / Criteria
  - Infrastructure Elements
  - Climate
  - Time Horizon
  - Geographical Setting
  - Applicable Jurisdictions

# DEFINING THE SCOPE - STEP 1


- Team Resources may include:
  - Risk assessment specialist(s)
  - Climate specialist(s)
  - Planners / Technical / Professional Engineer(s)
  - Natural Environment Subject Matter Expert
  - Operation & Maintenance
  - Management, Finance, Legal
  - Non-organizational stakeholders
  - Indigenous

# Defining the Scope - Step 1

- Elements
  - Highway
  - Bridge
  - Adjacent Infrastructure
  - Buildings

# Defining the Scope - Step 1

- Climate

| | |
|---|---|
| Temperature | Mean values<br>Extremes |
| Precipitation as Rain | Frequency and Intensity<br>Annual/seasonal precipitation and rain<br>Drought conditions |
| Precipitation as Snow | Annual/seasonal precipitation and snow<br>Magnitude of snow events<br>Rain on snow events |
| Hail | Frequency of events<br>Magnitude of events |
| Ice Accretion | Ice storm events<br>Ice buildup on infrastructure |
| Flooding | River / Lake Flooding<br>Flooding (precipitation) |
| Fog | Frequency<br>Visibility |
| Ice | River or lake ice |
| Frost | Freeze thaw cycles<br>Change in frost season |
| Wind Speed | Extreme gusts / Thunderstorm winds<br>Tornado event frequency/intensity |
| Fire | Wildfire / Smoke |
| Lightning | Lightning |

# Defining the Scope - Step 1

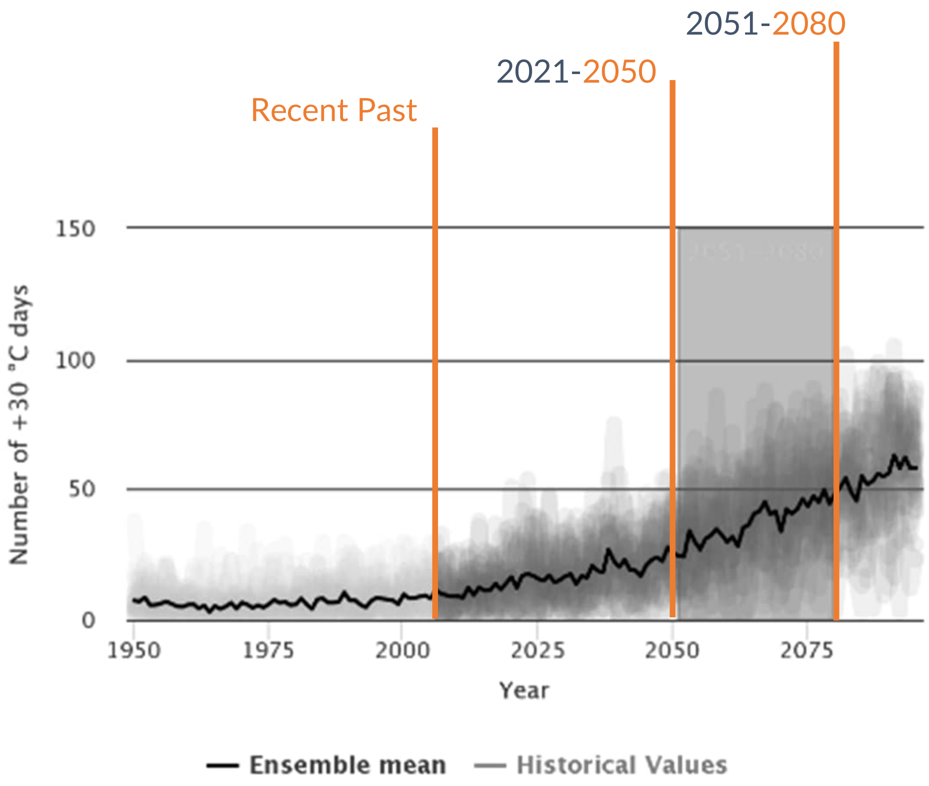
- Climate

| | |
|---|---|
| Temperature | Mean values<br>Extremes |
| Precipitation as Rain | Frequency and Intensity<br>Annual/seasonal precipitation and rain<br>Drought conditions |
| Precipitation as Snow | Annual/seasonal precipitation and snow<br>Magnitude of snow events<br>Rain on snow events |
| Hail | Frequency of events<br>Magnitude of events |
| Ice Accretion | Ice storm events<br>Ice buildup on infrastructure |
| Flooding | River / Lake Flooding<br>Flooding (precipitation) |
| Fog | Frequency<br>Visibility |
| Ice | River or lake ice |
| Frost | Freeze thaw cycles<br>Change in frost season |
| Wind Speed | Extreme gusts / Thunderstorm winds<br>Tornado event frequency/intensity |
| Fire | Wildfire / Smoke |
| Lightning | Lightning |

# Defining the Scope - Step 1

- Time Horizon

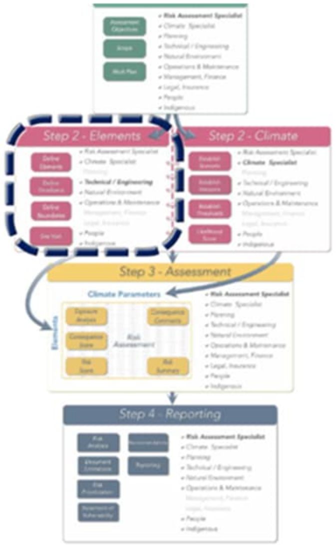
| | Expected Lifecycle |
|---|---|
| Dams/<br>Water Supply | Base system 50-100 yrs<br>Refurbishment 20-30 yrs<br>Reconstruction 50 yrs |
| Storm/Sanitary<br>Sewer | Base system 100 yrs<br>Major upgrade 50 yrs<br>Components 25 – 50 yrs |
| Roads &<br>Bridges | Road surface 10 - 20 yrs<br>Bridges 50 - 100 yrs<br>Maintenance annually<br>Resurface concrete 20-25 yrs<br>Reconstruction 50-100 yrs |
| Houses/<br>Buildings | Retrofit/alterations 15-20 yrs<br>Demolition 50-100 yrs |



# Defining the Scope - Step 1

- Geographical Setting and Jurisdictions
  - Provincial
  - Municipal
  - Private

# Defining Elements - Step 2

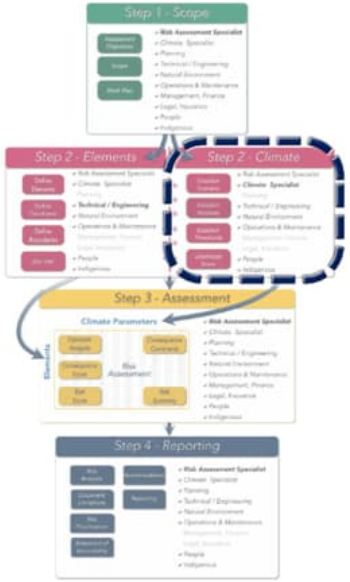




# Defining Elements - Step 2




| Highway | Bridge | Adjacent Infrastructure | Building |
|---|---|---|---|
| Road | Bridge | Facilities | • Envelope |
| • Pavement Structure | • Bridge Substructure | • Industry Sites | • Roofing |
| • Embankments | • Bridge Superstructure | • MB Public Works Yard | • Foundation |
| Drainage | • Bridge Deck | • Roads and Paths | • HVAC Components |
| • Culverts | • Joints and Bearings | • Rail Infrastructure | • Building Controls, Automation |
| • Ditches | • Drainage | • Water and Wastewater Facilities | • Life Safety (Fire) |
| Highway Safety | Bridge Safety | • Community Buildings / Schools | • Plumbing |
| • Maintenance | • Railings | • Public Areas (trails, parks) | • Lighting |
| • Guardrails | • Maintenance | • Drainage Infrastructure | • Communication and Security |
| • Signage | Little Saskatchewan River | • River | • Electrical |
| • Lighting | • River (elevation) | • Maintenance | • Drainage, Parking, Site |

# DEFINING CLIMATE - STEP 2


- Collect data on:
  - Climate Scenario
    - Baseline Climate (Recent Past)
    - Climate Change (2050, 2080)
    - Time Horizon
  - Establish level of precision
  - Level of assessment ⇒ Level of detail

# Defining Climate - Step 2

- Climate Resources
  - Climate West (climatewest.ca)
  - ClimateData.ca
  - Climate Atlas of Canada (climateatlas.ca)
  - PARC Data Applications (www.parc.ca)
  - Flood Mapping, Flood Studies, Modeling
  - Refined data sets and technical documents prepared by municipalities


Prairie Climate Centre

# DEFINING CLIMATE - STEP 2

- Climate Atlas of Canada
  - Minnedosa

## Climate Atlas Report
### Municipality: Minnedosa



**RCP 8.5: High Carbon climate future**
GHG emissions continue to increase at current rates

| Variable | Period | 1976-2005 Mean | 2021-2050 Low | 2021-2050 Mean | 2021-2050 High | 2051-2080 Low | 2051-2080 Mean | 2051-2080 High |
|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | annual | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Precipitation (mm) | spring | 107 | 90 | 119 | 187 | 87 | 129 | 195 |
| Precipitation (mm) | summer | 230 | 121 | 211 | 313 | 110 | 201 | 300 |
| Precipitation (mm) | fall | 100 | 52 | 109 | 176 | 95 | 108 | 173 |
| Precipitation (mm) | winter | 66 | 43 | 73 | 109 | 46 | 79 | 118 |
| Mean Temperature (°C) | annual | 1.4 | 2 | 3.7 | 5.5 | 4 | 6.2 | 8.3 |
| Mean Temperature (°C) | spring | 1.3 | 0.2 | 3.5 | 6.7 | 2.4 | 5.6 | 9 |
| Mean Temperature (°C) | summer | 16.7 | 17 | 18.9 | 20.8 | 16.7 | 21.2 | 23.5 |
| Mean Temperature (°C) | fall | 3 | 2 | 5.2 | 7.3 | 5.3 | 7.5 | 9.9 |
| Mean Temperature (°C) | winter | -15.8 | -16.9 | -13 | -9.5 | -14 | -10 | -6.9 |
| Tropical Nights | annual | 0 | 0 | 1 | 5 | 0 | 6 | 20 |
| Very hot days (+30 °C) | annual | 7 | 5 | 11 | 28 | 14 | 35 | 62 |
| Very cold days (-30°C) | annual | 18 | 1 | 8 | 19 | 0 | 3 | 0 |
| Date of Last Spring Frost | annual | May 21 | April 27 | May 13 | May 30 | April 13 | May 4 | May 21 |
| Date of First Fall Frost | annual | Sep. 18 | Sep. 3 | Sep. 29 | Oct. 18 | Sep. 20 | Oct. 9 | Oct. 28 |
| Frost-Free Season (days) | annual | 116 | 103 | 135 | 166 | 127 | 154 | 184 |

**RCP 4.5: Low Carbon climate future**
GHG emissions much reduced

| Variable | Period | 1976-2005 Mean | 2021-2050 Low | 2021-2050 Mean | 2021-2050 High | 2051-2080 Low | 2051-2080 Mean | 2051-2080 High |
|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | annual | 481 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Precipitation (mm) | spring | 107 | 90 | 118 | 185 | 82 | 119 | 185 |
| Precipitation (mm) | summer | 295 | 124 | 205 | 330 | 118 | 204 | 330 |
| Precipitation (mm) | fall | 100 | 54 | 107 | 174 | 53 | 108 | 172 |
| Precipitation (mm) | winter | 66 | 44 | 74 | 111 | 44 | 78 | 113 |
| Mean Temperature (°C) | annual | 1.4 | 1.8 | 3.5 | 5.3 | 2.8 | 4.7 | 6.7 |
| Mean Temperature (°C) | spring | 1.3 | 0.3 | 3.4 | 5.6 | 1.5 | 4.5 | 7.7 |
| Mean Temperature (°C) | summer | 16.7 | 16.7 | 18.5 | 20.2 | 17.0 | 19.6 | 21.7 |
| Mean Temperature (°C) | fall | 3 | 3.8 | 5 | 7.1 | 3.6 | 6 | 8.2 |
| Mean Temperature (°C) | winter | -15.8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Tropical Nights | annual | 0 | 0 | 1 | 4 | 0 | 1 | 0 |
| Very hot days (+30 °C) | annual | 7 | 5 | 17 | 33 | 8 | 25 | 45 |
| Very cold days (-30°C) | annual | 18 | 1 | 9 | 21 | 8 | 5 | 14 |
| Date of Last Spring Frost | annual | May 21 | April 30 | May 15 | June 2 | April 21 | May 11 | May 28 |
| Date of First Fall Frost | annual | Sep. 18 | Sep. 8 | Sep. 28 | Oct. 14 | Sep. 12 | Sep. 30 | Oct. 19 |
| Frost-Free Season (days) | annual | 116 | 109 | 131 | 155 | 111 | 138 | 180 |

# DEFINING CLIMATE - STEP 2

## Climate Atlas Report
### Municipality: Minnedosa



**RCP 8.5: High Carbon climate future**
GHG emissions continue to increase at current rates

| Variable | Period | 1976-2005 Mean | 2021-2050 Low | 2021-2050 Mean | 2021-2050 High | 2051-2080 Low | 2051-2080 Mean | 2051-2080 High |
|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | annual | 480 | 376 | 511 | 656 | 375 | 513 | 665 |
| Precipitation (mm) | spring | 107 | 60 | 119 | 187 | 67 | 126 | 199 |
| Precipitation (mm) | summer | 208 | 121 | 211 | 313 | 110 | 201 | 308 |
| Precipitation (mm) | fall | 100 | 52 | 109 | 178 | 55 | 108 | 173 |
| Precipitation (mm) | winter | 66 | 43 | 73 | 109 | 46 | 79 | 118 |
| Mean Temperature (°C) | annual | 1.4 | 2 | 3.7 | 5.5 | 4 | 6.2 | 8.3 |
| Mean Temperature (°C) | spring | [illegible] | 0.2 | [illegible] | 6.7 | 2.4 | [illegible] | 9 |
| Mean Temperature (°C) | summer | 16.7 | 17 | 18.9 | 20.8 | 18.7 | 21.2 | 23.5 |
| Mean Temperature (°C) | fall | 3 | 3 | 5.2 | 7.3 | 5.3 | 7.5 | 9.8 |
| Mean Temperature (°C) | winter | -15.8 | -16.9 | -13 | -9.3 | -14 | -10 | -5.9 |
| Tropical Nights | annual | 0 | 0 | 1 | 5 | 0 | 8 | 20 |
| Very hot days (+30°C) | annual | 7 | 5 | 19 | 36 | 14 | 38 | 62 |
| Very cold days (-30°C) | annual | 18 | 1 | 8 | 19 | 0 | 3 | 8 |
| Date of Last Spring Frost | annual | May 21 | April 27 | May 13 | May 30 | April 13 | May 4 | May 21 |
| Date of First Fall Frost | annual | Sep. 18 | Sep. 9 | Sep. 28 | Oct. 18 | Sep. 20 | Oct. 9 | Oct. 28 |
| Frost-Free Season (days) | annual | 116 | 109 | 135 | 160 | 127 | 154 | 184 |

# DEFINING CLIMATE - STEP 2

- Likelihood Scores

| Likelihood Score (L) | Middle Baseline Approach - Establish Base | Method |
|---|---|---|
| 1 | ▲ | Likely to occur less frequently than current climate |
| 2 | | |
| 3 | Establish Current Climate Baseline Per Parameter | Likely to occur as frequently as current climate |
| 4 | | |
| 5 | ▼ | Likely to occur more frequently than current climate |

# DEFINING CLIMATE - STEP 2

**RCP 8.5: High Carbon climate future**
GHG emissions continue to increase at current rates

| Variable | Period | 1976-2005 Mean | 2021-2050 Low | 2021-2050 Mean | 2021-2050 High | 2051-2080 Low | 2051-2080 Mean | 2051-2080 High |
|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | annual | 480 | 376 | 511 | 656 | 375 | 513 | 665 |
| Precipitation (mm) | spring | 107 | 60 | 119 | 187 | 67 | 126 | 199 |
| Precipitation (mm) | summer | 208 | 121 | 211 | 313 | 110 | 201 | 308 |
| Precipitation (mm) | fall | 100 | 52 | 109 | 178 | 55 | 108 | 173 |
| Precipitation (mm) | winter | 66 | 43 | 73 | 109 | 46 | 79 | 118 |
| Mean Temperature (°C) | annual | 1.4 | 2 | 3.7 | 5.5 | 4 | 6.2 | 8.3 |
| Mean Temperature (°C) | spring | [illegible] | 0.2 | [illegible] | 6.7 | 2.4 | [illegible] | 9 |
| Mean Temperature (°C) | summer | 16.7 | 17 | 18.9 | 20.8 | 18.7 | 21.2 | 23.5 |

| | Annual | |
|---|---|---|
| | Mean Temperature (deg C) | |
| Present | 1.4 | 3 |
| 2050 | 3.7 | 4 |
| 2080 | 6.2 | 5 |

| Likelihood Score (L) | Middle Baseline Approach - Establish Base | Method |
|---|---|---|
| 1 | ▲ | Likely to occur less frequently than current climate |
| 2 | | |
| 3 | Establish Current Climate Baseline Per Parameter | Likely to occur as frequently as current climate |
| 4 | | |
| 5 | ▼ | Likely to occur more frequently than current climate |

# Defining Climate - Step 2

| | Temperature | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual | | Summer | | Winter | | Extreme | | Extreme | | Freeze Thaw | |
| | Mean Temperature (deg C) | | Mean Temperature (deg C) | | Mean Temperature (deg C) | | Very Hot Days (+30 deg C) | | Very Cold Days (-30 deg C) | | Freeze Thaw Cycles | |
| Present | 1.4 | 3 | 16.7 | 3 | -15.8 | 3 | 7 | 3 | 18 | 3 | 72.6 | 3 |
| 2050 | 3.7 | 4 | 18.9 | 4 | -13 | 2 | 19 | 4 | 8 | 2 | 66.5 | 2 |
| 2080 | 6.2 | 5 | 21.2 | 5 | -10 | 2 | 38 | 5 | 3 | 1 | 64.1 | 2 |

Climate Atlas Data or Projection

Assigned Likelihood Score

# Defining Climate - Step 2

| | Precipitation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual | | Intensity | | Intensity | | Drought Conditions | | Winter Precipitation | | Ice Storms | |
| | Annual Precipitation (mm) | | Five Day Max Precipitation (mm) | | Heavy Precipitation Days (20 mm) | | Dry Days | | Snow (mm) | | Ice Storms | |
| Present | 480 | 3 | 56 | 3 | 3 | 3 | 245.6 | 3 | 66 | 3 | | 3 |
| 2050 | 511 | 4 | 61 | 3 | 3.5 | 4 | 244.7 | 3 | 73 | 4 | + | 4 |
| 2080 | 513 | 4 | 61 | 3 | 3.4 | 4 | 245.8 | 3 | 79 | 4 | + | 5 |

Climate Atlas Data or Projection

Assigned Likelihood Score

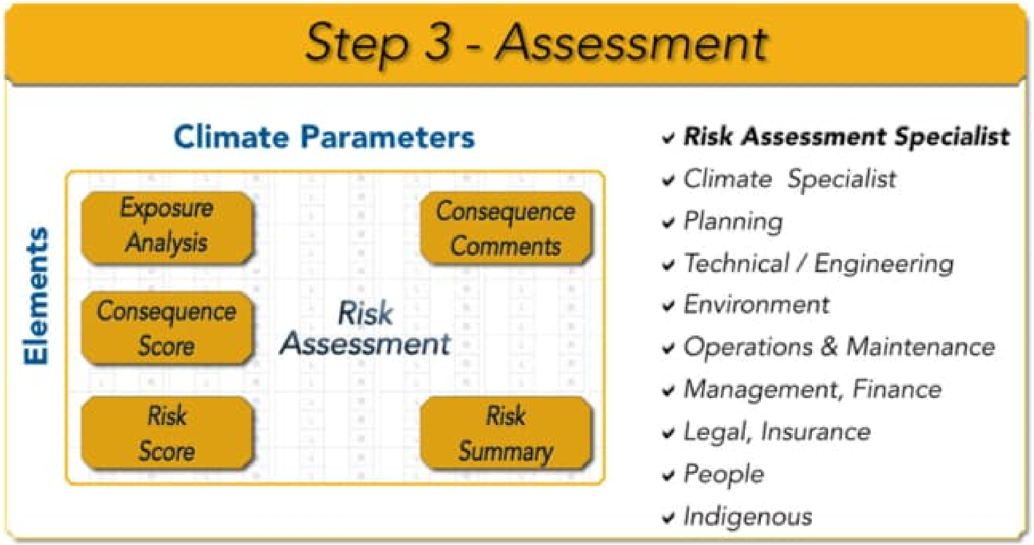
# Defining Climate - Step 2

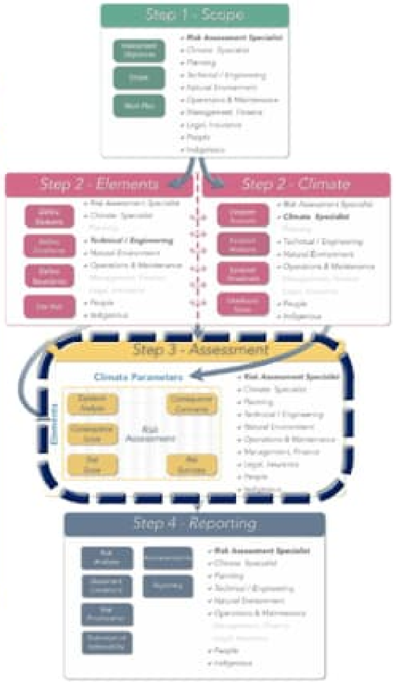
| | Extreme Events | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Extreme Winds | | | Lightning | | | Flood | | | Wildfire / Smoke | | |
| | Tornado | | | Lightning | | | Flood Risk Report / Ice Jams | | | Fire | | |
| Present | | 3 | | | 3 | | | 3 | | | 3 | |
| 2050 | + | 4 | | + | 4 | | + | 4 | | + | 4 | |
| 2080 | + | 5 | | + | 5 | | + | 5 | | + | 5 | |

Climate Atlas Data or Projection

Assigned Likelihood Score

# ASSESSING RISK – STEP 3




- Important considerations:
  - Risk tolerance
  - Are climate interactions possible?
  - Cumulative or combination events
  - Likelihood scoring
  - Consequence scoring
  - Judgments on uncertainties

# Assessing Risk – Step 3

- Risk (R) is defined as the product of the Likelihood (L) of an event and the Consequence (C) of that event – should it occur (Exposure)(E).
  - R = E x L x C

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | CONSEQUENCE | Catastrophic | 0 | 5 | 10 | 15 | 20 | 25 |
| 4 | | Major | 0 | 4 | 8 | 12 | 16 | 20 |
| 3 | | Moderate | 0 | 3 | 6 | 9 | 12 | 15 |
| 2 | | Minor | 0 | 2 | 4 | 6 | 8 | 10 |
| 1 | | Insignificant | 0 | 1 | 2 | 3 | 4 | 5 |
| 0 | | No Effect | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Negligible Not Applicable | Highly Unlikely Improbable | Remotely Possible | Possible Occasional | Somewhat Likely Normal | Likely Frequent |
| | | | LIKELIHOOD | | | | | |
| | | | 0 | 1 | 2 | 3 | 4 | 5 |

# Assessing Risk – Step 3

- Risk Assessment Worksheet

Climate Parameters

Elements

Consequence Score
0 - No Effect
1 - Insignificant
2 - Minor
3 - Moderate
4 - Major
5 - Catastrophic

Climate Parameter

| | | | Temperature | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual | | | | Summer | | | | Winter | | | | Extreme | | | | Extreme | | | | Freeze Thaw | | | |
| | | | Mean Temperature (deg C) | | | | Mean Temperature (deg C) | | | | Mean Temperature (deg C) | | | | Very Hot Days (+30 deg C) | | | | Very Cold Days (-30 deg C) | | | | Freeze Thaw Cycles | | | |
| Climate Projections (Climate Atlas - RCP 8.5) | | Present | 1.9 | 3 | | | 15 | 3 | | | -13 | 3 | | | 2 | 3 | | | 15 | 3 | | | 86.5 | 3 | | |
| | | 2050 | 3.9 | 4 | | | 17 | 4 | | | -10.6 | 2 | | | 7 | 4 | | | 8 | 2 | | | 75.3 | 2 | | |
| | | 2080 | 6 | 5 | | | 19.1 | 5 | | | -8.2 | 2 | | | 18 | 5 | | | 4 | 1 | | | 67.2 | 2 | | |
| Infrastructure Components | | | 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 |
| **Highway** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Road** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pavement Structure | 1 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| Embankments | 2 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| **Drainage** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Culverts | 3 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| Ditches | 4 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| **Highway Safety** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maintenance | 5 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| Guardrails | 6 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| Signage | 7 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | | 0 |
| | | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 0 |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | Precipitation | | | | | | | | | | | | | | | | | | | | | | | | | | | | Extreme Event | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual | | | | Intensity | | | | Intensity | | | | Drought Conditions | | | | Winter Precipitation | | | | Ice Storms | | | | Extreme Winds | | | | Lightning | | | | Flo | |
| | | | Annual Precipitation (mm) | | | | Five Day Max Precipitation (mm) | | | | Heavy Precipitation Days (20 mm) | | | | Dry Days | | | | Snow (mm) | | | | Ice Storms | | | | Tornado | | | | Lightning | | | | Flood Ri / Ice | |
| Climate Projections (Climate Atlas - RCP 8.5) | | Present | 444 | 3 | | | 51 | 3 | | | 1.8 | 3 | | | 238.9 | 3 | | | 83 | 3 | | | | 3 | | | | 3 | | | | 3 | | | | 3 |
| | | 2050 | 470 | 4 | | | 54 | 3 | | | 2.1 | 4 | | | 238.2 | 3 | | | 90 | 4 | | | + | 4 | | | + | 4 | | | + | 4 | | | + | 4 |
| | | 2080 | 498 | 5 | | | 57 | 3 | | | 2.3 | 4 | | | 238.1 | 3 | | | 96 | 4 | | | + | 5 | | | + | 5 | | | + | 5 | | | + | 5 |
| Infrastructure Components | | | 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 |
| **Highway** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Road** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pavement Structure | 1 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| Embankments | 2 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| **Drainage** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Culverts | 3 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| Ditches | 4 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| **Highway Safety** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maintenance | 5 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| Guardrails | 6 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| Signage | 7 | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 |
| | | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | | 4 |
| | | 2080 | | 5 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# Assessing Risk – Step 3

- Risk Assessment (Workshop)
  - Working as a Group
  - Review infrastructure components and climate data
  - Evaluate if each infrastructure component will interact with/exposed to a given climate parameter (E)
  - Evaluate the consequence of the climate interaction. Assign a Consequence Score (C)
  - Review risk assessment results and discuss how the risks could be addressed

# Assessing Risk – Step 3

- Risk Assessment (Workshop)
  - Evaluate if a given infrastructure component will is exposed to a given climate parameter (E): Yes (1) / No (0)
  - Evaluate the consequence of the climate interaction. Assign a Consequence Score (C)

| Score | Consequence |
|---|---|
| | Method D |
| 0 | No Effect |
| 1 | Insignificant |
| 2 | Minor |
| 3 | Moderate |
| 4 | Major |
| 5 | Catastrophic |

- Review Likelihood (L) value provided.
- Review Risk Scores (R) for each item

| Risk = Likelihood x Consequence |
|---|
| Low Risk |
| Medium Risk |
| High Risk |

# Assessing Risk – Step 3

Consequence Score
- 0 - No Effect
- 1 - Insignificant
- 2 - Minor
- 3 - Moderate
- 4 - Major
- 5 - Catastrophic

Climate Parameter

**Temperature**

| Infrastructure Components | | Annual – Mean Temperature (deg C) | | | | Summer – Mean Temperature (deg C) | | | | Winter – Mean Temperature (deg C) | | | | Extreme – Very Hot Days (+30 deg C) | | | | Extreme – Very Cold Days (-30 deg C) | | | | Freeze Thaw – Freeze Thaw Cycles | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 |
| Climate Projections (Climate Atlas - RCP 8.5) | Present | 1.4 | 3 | | | 16.7 | 3 | | | -15.8 | 3 | | | 7 | 3 | | | 18 | 3 | | | 72.6 | 3 | | |
| | 2050 | 3.7 | 4 | | | 18.9 | 4 | | | -13 | 2 | | | 19 | 4 | | | 8 | 2 | | | 66.5 | 2 | | |
| | 2080 | 6.2 | 5 | | | 21.2 | 5 | | | -10 | 2 | | | 38 | 5 | | | 3 | 1 | | | 64.1 | 2 | | |
| **Highway** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Road** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Pavement Structure | Present | | 3 | | 0 | | 3 | | 12 | | 3 | | 15 | | 3 | | 9 | | 3 | | 12 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | Y | 4 | 4 | 16 | Y | 2 | 5 | 10 | Y | 4 | 3 | 12 | Y | 2 | 4 | 8 | Y | 2 | 4 | 8 |
| | 2080 | | 5 | | 0 | | 5 | | 20 | | 2 | | 10 | | 5 | | 15 | | 1 | | 4 | | 2 | | 8 |
| 2 Embankments | Present | | 3 | | 6 | | 3 | | 6 | | 3 | | 6 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | Y | 4 | 2 | 8 | y | 4 | 2 | 8 | y | 2 | 2 | 4 | | 4 | | 0 | | 2 | | 0 | y | 2 | 3 | 6 |
| | 2080 | | 5 | | 10 | | 5 | | 10 | | 2 | | 4 | | 5 | | 0 | | 1 | | 0 | | 2 | | 6 |
| **Drainage** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Culverts | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | y | 2 | 3 | 6 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 6 |
| 4 Ditches | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | | 2 | 3 | 6 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 6 |
| **Highway Safety** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 Maintenance | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 6 | | 3 | | 12 | | 3 | | 12 | | 3 | | 0 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | y | 2 | 2 | 4 | y | 4 | 4 | 16 | y | 2 | 4 | 8 | | 2 | | 0 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 4 | | 5 | | 20 | | 1 | | 4 | | 2 | | 0 |
| 6 Guardrails | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | y | 2 | 3 | 6 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 6 |
| 7 Signage | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | y | 4 | 3 | 12 | | 2 | | 0 | y | 2 | 3 | 6 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 15 | | 1 | | 0 | | 2 | | 6 |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 Bridge Substructure / Foundation | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 2 | | 0 | | 4 | | 0 | | 2 | | 0 | y | 2 | 3 | 6 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 2 | | 0 | | 5 | | 0 | | 1 | | 0 | | 2 | | 6 |
| 9 Bridge Superstructure | Present | | 3 | | 0 | | 3 | | 9 | | 3 | | 9 | | 3 | | 12 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | y | 4 | 3 | 12 | y | 2 | 3 | 6 | y | 4 | 4 | 16 | y | 2 | 3 | 6 | y | 2 | 4 | 8 |
| | 2080 | | 5 | | 0 | | 5 | | 15 | | 2 | | 6 | | 5 | | 20 | | 1 | | 3 | | 2 | | 8 |
| 10 Bridge Deck | Present | | 3 | | 0 | | 3 | | 9 | | 3 | | 9 | | 3 | | 12 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | y | 4 | 3 | 12 | y | 2 | 3 | 6 | y | 4 | 4 | 16 | y | 2 | 3 | 6 | y | 2 | 4 | 8 |
| | 2080 | | 5 | | 0 | | 5 | | 15 | | 2 | | 6 | | 5 | | 20 | | 1 | | 3 | | 2 | | 8 |

**Precipitation**

| Infrastructure Components | | Annual – Annual Precipitation (mm) | | | | Intensity – Five Day Max Precipitation (mm) | | | | Intensity – Heavy Precipitation Days (20 mm) | | | | Drought Conditions – Dry Days | | | | Winter Precipitation – Snow (mm) | | | | Ice Storms – Ice Storms | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 |
| Climate Projections (Climate Atlas - RCP 8.5) | Present | 480 | 3 | | | 56 | 3 | | | 3 | 3 | | | 245.6 | 3 | | | 66 | 3 | | | | 3 | | |
| | 2050 | 511 | 4 | | | 61 | 3 | | | 3.5 | 4 | | | 244.7 | 3 | | | 73 | 4 | | | + | 4 | | |
| | 2080 | 513 | 4 | | | 61 | 3 | | | 3.4 | 4 | | | 245.8 | 3 | | | 79 | 4 | | | + | 5 | | |
| **Highway** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Road** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Pavement Structure | Present | | 3 | | 6 | | 3 | | 9 | | 3 | | 12 | | 3 | | 9 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | Y | 4 | 2 | 8 | Y | 3 | 3 | 9 | Y | 4 | 4 | 16 | Y | 3 | 3 | 9 | Y | 4 | 3 | 12 | Y | 4 | 4 | 16 |
| | 2080 | | 4 | | 8 | | 3 | | 9 | | 4 | | 16 | | 3 | | 9 | | 4 | | 12 | | 5 | | 20 |
| 2 Embankments | Present | | 3 | | 9 | | 3 | | 12 | | 3 | | 12 | | 3 | | 9 | | 3 | | 9 | | 3 | | 0 |
| | 2050 | y | 4 | 3 | 12 | y | 3 | 4 | 12 | y | 4 | 4 | 16 | y | 3 | 3 | 9 | y | 4 | 3 | 12 | | 4 | | 0 |
| | 2080 | | 4 | | 12 | | 3 | | 12 | | 4 | | 16 | | 3 | | 9 | | 4 | | 12 | | 5 | | 0 |
| **Drainage** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Culverts | Present | | 3 | | 6 | | 3 | | 12 | | 3 | | 12 | | 3 | | 6 | | 3 | | 9 | | 3 | | 0 |
| | 2050 | y | 4 | 2 | 8 | y | 3 | 4 | 12 | y | 4 | 4 | 16 | y | 3 | 2 | 6 | y | 4 | 3 | 12 | | 4 | | 0 |
| | 2080 | | 4 | | 8 | | 3 | | 12 | | 4 | | 16 | | 3 | | 6 | | 4 | | 12 | | 5 | | 0 |
| 4 Ditches | Present | | 3 | | 6 | | 3 | | 12 | | 3 | | 12 | | 3 | | 6 | | 3 | | 9 | | 3 | | 0 |
| | 2050 | y | 4 | 2 | 8 | y | 3 | 4 | 12 | y | 4 | 4 | 16 | y | 3 | 2 | 6 | y | 4 | 3 | 12 | | 4 | | 0 |
| | 2080 | | 4 | | 8 | | 3 | | 12 | | 4 | | 16 | | 3 | | 6 | | 4 | | 12 | | 5 | | 0 |
| **Highway Safety** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 Maintenance | Present | | 3 | | 0 | | 3 | | 9 | | 3 | | 12 | | 3 | | 6 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | y | 3 | 3 | 9 | y | 4 | 4 | 16 | y | 3 | 2 | 6 | y | 4 | 3 | 12 | y | 4 | 4 | 16 |
| | 2080 | | 4 | | 0 | | 3 | | 9 | | 4 | | 16 | | 3 | | 6 | | 4 | | 12 | | 5 | | 20 |
| 6 Guardrails | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 | | 3 | | 0 | | 3 | | 9 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 3 | | 0 | y | 4 | 3 | 12 | | 3 | | 0 | y | 4 | 3 | 12 | y | 4 | 3 | 12 |
| | 2080 | | 4 | | 0 | | 3 | | 0 | | 4 | | 12 | | 3 | | 0 | | 4 | | 12 | | 5 | | 15 |
| 7 Signage | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 | | 3 | | 0 | | 3 | | 12 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 3 | | 0 | y | 4 | 3 | 12 | | 3 | | 0 | y | 4 | 4 | 16 | y | 4 | 3 | 12 |
| | 2080 | | 4 | | 0 | | 3 | | 0 | | 4 | | 12 | | 3 | | 0 | | 4 | | 16 | | 5 | | 15 |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Bridge** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 Bridge Substructure / Foundation | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 |
| | 2050 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 4 | | 0 |
| | 2080 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 3 | | 0 | | 4 | | 0 | | 5 | | 0 |
| 9 Bridge Superstructure | Present | | 3 | | 0 | | 3 | | 9 | | 3 | | 12 | | 3 | | 0 | | 3 | | 9 | | 3 | | 0 |
| | 2050 | | 4 | | 0 | y | 3 | 3 | 9 | y | 4 | 4 | 16 | | 3 | | 0 | y | 4 | 3 | 12 | | 4 | | 0 |
| | 2080 | | 4 | | 0 | | 3 | | 9 | | 4 | | 16 | | 3 | | 0 | | 4 | | 12 | | 5 | | 0 |
| 10 Bridge Deck | Present | | 3 | | 0 | | 3 | | 9 | | 3 | | 12 | | 3 | | 0 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | y | 3 | 3 | 9 | y | 4 | 4 | 16 | | 3 | | 0 | y | 4 | 3 | 12 | y | 4 | 4 | 16 |
| | 2080 | | 4 | | 0 | | 3 | | 9 | | 4 | | 16 | | 3 | | 0 | | 4 | | 12 | | 5 | | 20 |

**Extreme Events**

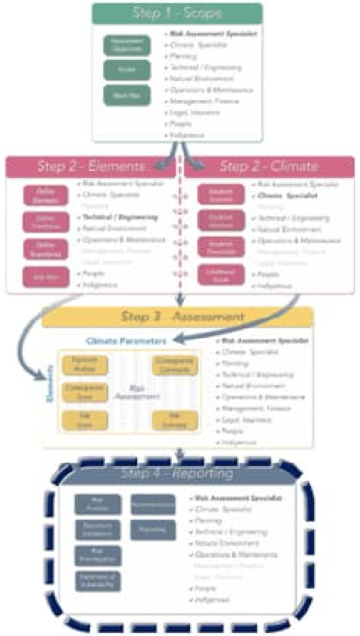
| Infrastructure Components | | Extreme Winds – Tornado | | | | Lightning – Lightning | | | | Flood – Flood Risk Report / Ice Jams | | | | Wildfire / Smoke – Fire | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Y/N | L | C | R | Y/N | L | C | R | Y/N | L | C | R | Y/N | L | C | R |
| Climate Projections (Climate Atlas - RCP 8.5) | Present | | 3 | | | | 3 | | | | 3 | | | | 3 | | |
| | 2050 | + | 4 | | | + | 4 | | | + | 4 | | | + | 4 | | |
| | 2080 | + | 5 | | | + | 5 | | | + | 5 | | | + | 5 | | |
| **Highway** | | | | | | | | | | | | | | | | | |
| **Road** | | | | | | | | | | | | | | | | | |
| 1 Pavement Structure | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | Y | 4 | 3 | 12 | Y | 4 | 3 | 12 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 15 | | 5 | | 15 |
| 2 Embankments | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | y | 4 | 3 | 12 | y | 4 | 4 | 16 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 15 | | 5 | | 20 |
| **Drainage** | | | | | | | | | | | | | | | | | |
| 3 Culverts | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 12 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | y | 4 | 4 | 16 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 20 | | 5 | | 15 |
| 4 Ditches | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 12 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | y | 4 | 4 | 16 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 20 | | 5 | | 15 |
| **Highway Safety** | | | | | | | | | | | | | | | | | |
| 5 Maintenance | Present | | 3 | | 12 | | 3 | | 12 | | 3 | | 9 | | 3 | | 12 |
| | 2050 | y | 4 | 4 | 16 | y | 4 | 4 | 16 | y | 4 | 3 | 12 | y | 4 | 4 | 16 |
| | 2080 | | 5 | | 20 | | 5 | | 20 | | 5 | | 15 | | 5 | | 20 |
| 6 Guardrails | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | | 4 | | 0 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 0 | | 5 | | 15 |
| 7 Signage | Present | | 3 | | 12 | | 3 | | 0 | | 3 | | 0 | | 3 | | 9 |
| | 2050 | y | 4 | 4 | 16 | | 4 | | 0 | | 4 | | 0 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 20 | | 5 | | 0 | | 5 | | 0 | | 5 | | 15 |
| **Bridge** | | | | | | | | | | | | | | | | | |
| **Bridge** | | | | | | | | | | | | | | | | | |
| 8 Bridge Substructure / Foundation | Present | | 3 | | 0 | | 3 | | 0 | | 3 | | 12 | | 3 | | 12 |
| | 2050 | | 4 | | 0 | | 4 | | 0 | y | 4 | 4 | 16 | y | 4 | 4 | 16 |
| | 2080 | | 5 | | 0 | | 5 | | 0 | | 5 | | 20 | | 5 | | 20 |
| 9 Bridge Superstructure | Present | | 3 | | 9 | | 3 | | 0 | | 3 | | 6 | | 3 | | 9 |
| | 2050 | y | 4 | 3 | 12 | | 4 | | 0 | y | 4 | 2 | 8 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 15 | | 5 | | 0 | | 5 | | 10 | | 5 | | 15 |
| 10 Bridge Deck | Present | | 3 | | 9 | | 3 | | 0 | | 3 | | 6 | | 3 | | 9 |
| | 2050 | y | 4 | 3 | 12 | | 4 | | 0 | y | 4 | 2 | 8 | y | 4 | 3 | 12 |
| | 2080 | | 5 | | 15 | | 5 | | 0 | | 5 | | 10 | | 5 | | 15 |



ENGINEERS GEOSCIENTISTS MANITOBA

Associated STRATEGIC ADVISORY SERVICES

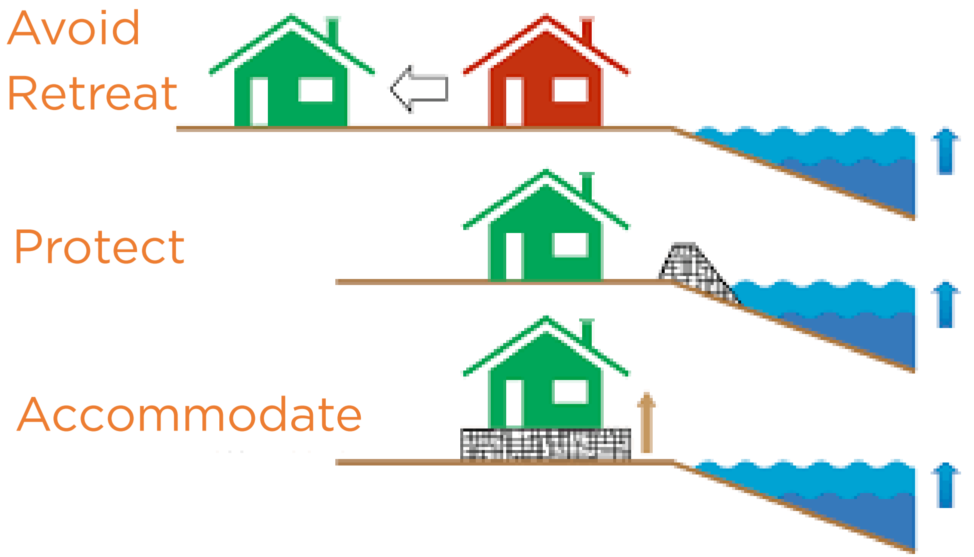
# Reporting – Step 4


- Evaluate Risk:
  - Summaries / Prioritize Risks (Low/ Medium High)
  - Review rational for consequent scoping
  - Begin to develop treatment options

# REPORTING – STEP 4

- Risk Treatment:
  - Risk mitigation / adaptation actions
    - No further action
    - Remedial action
      - Avoid / Retreat / Protect / Accommodate
    - Management action
    - Additional Study
  - Explore
    - **Natural Infrastructure**
    - **Mitigation** Opportunities
    - **Codes Standards** - CC Based



# Reporting – Step 4

- Example Project

| | Comments | Risk Action<br>Remedial Action<br>Management Action<br>No Further Action<br>Further Study or Work Requires |
|---|---|---|
| | | |
| **Highway** | | |
| **Road** | | |
| Pavement Structure | Medium risks were noted in the near and far future related to extreme high and low temperatures, high intensity rainfall events winter precipitation ice storms and wildfire smoke. High risks were identified in extreme heat and ice storms. | Remedial Action / Further Study: MI should review pavement structure design for increased temperature and impacts to surface during ice storms. |
| **Building** | | |
| HVAC Components | Medium risks were noted in the near and far future related to average temperature increases, extreme high and low temperatures, high intensity rainfall events winter precipitation ice storms, lightning and wildfire smoke. High risks were identified in extreme heat and wildfire smoke. | Remedial Action / Further Study: HVAC upgrades should consider future extreme temperatures. Increased wildfire smore may require upgrades to building filtration and air exchanges. Building should consider additional insulation, increased shading or other upgrades to reduce impacts to HVAC systems. |

- Upgrade to Heat Pumps
- Natural Infrastructure: Shading of Structures

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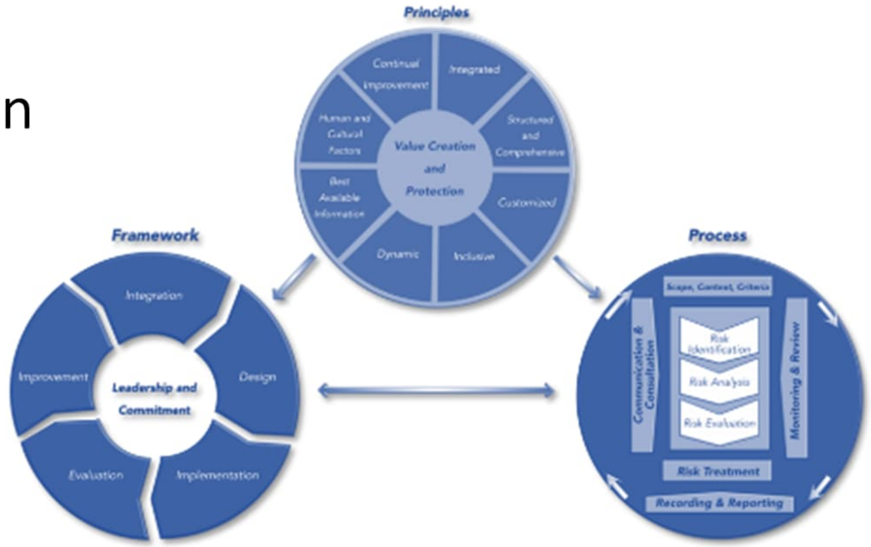
# REPORTING – STEP 4

- Next Steps:
  - Further risk assessment
  - Inform concept or planning phases of infrastructure on areas to adapt
  - Use the climate data and risks to inform design
  - Inform
    - operation and maintenance activities
    - upgrades on areas to adapt
    - adaptation plans
  - Mitigation Opportunities



# Reporting – Step 3

- Communication
  - Reporting / Presentations / Workshops / Stakeholder Engagement
  - Decision Making (Context)
  - Financial case study
  - Cost benefit analysis (cost of no action)
  - Triple Bottom Line analysis
  - Opportunities to integrate sustainable infrastructure (Natural Infrastructure)

# POLL

Poll: Where can a Climate Risk Assessment be applied? You can choose more than one

a) Asset management, capital and master planning.
b) Concept and preliminary engineering design.
c) Operations and management evaluation and review.
d) Infrastructure Canada's Climate Lens
e) Green and natural infrastructure assessments.
f) Informing Emergency Management and Business Continuity Management practices.
g) Informing climate change adaptation plans

# Questions?

ENGINEERS GEOSCIENTISTS MANITOBA

Contact: Jeff O’Driscoll, P.Eng., IRP, odriscollj@ae.ca

MANITOBA CLIMATE RESILIENCE TRAINING