INFRASTRUCTURE CLIMATE RISK ASSESSMENT - FEATURING THE PIEVC PROCESS

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Supported by Natural Resources Canada's Building Regional Adaptation Capacity and Expertise (BRACE) Program

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**
- Follow-up with **survey** and details of the presentation

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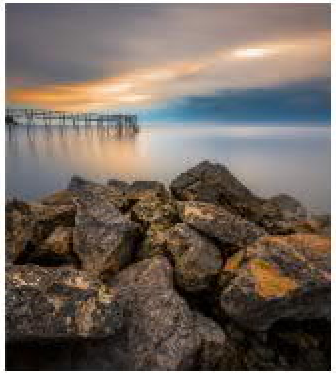
Course

- Overview and Highlights of Previous Courses
- Climate Change Resilience Assessment
- Example Project
- Defining the Scope of an Assessment
- Defining Climate Data
- Assessing Risk
- Evaluating and Treating Risk
- Question and Answer Session

Overview

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

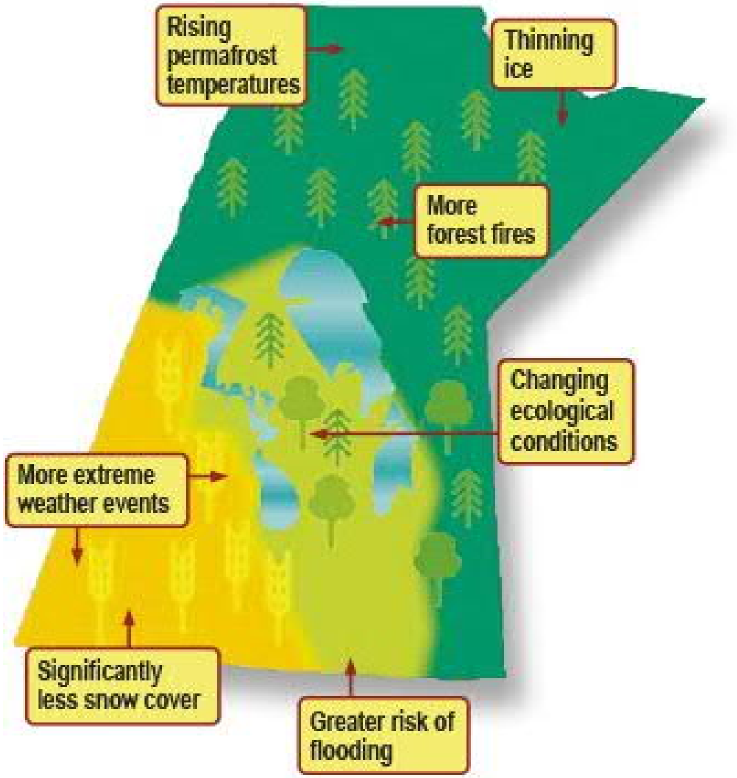


INFRASTRUCTURE CLIMATE RISK ASSESSMENT - FEATURING THE PIEVC PROCESS

Designing or building infrastructure to last? Using Manitoba-themed example projects and case studies, this course will provide PIEVC tools to conduct climate risk assessment on infrastructure systems.

- Prerequisites: Climate 101, Manitoba's Changing Climate, Climate Risk Assessment Core Principles
- Recommended prerequisite: Climate Change 101
- Week of January 24, 2022
- 90min
- Virtual
- Presented by Engineers Geoscientists Manitoba

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

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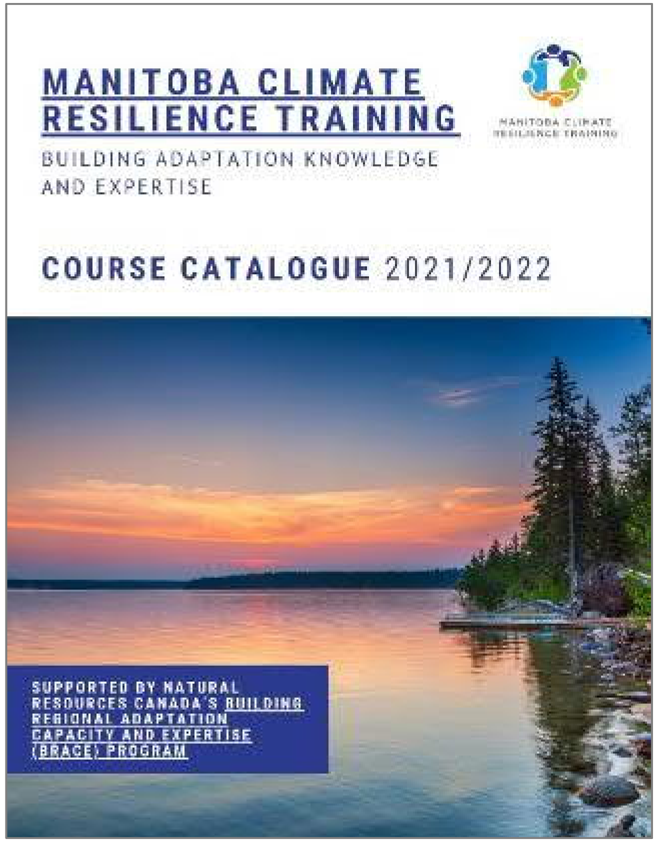
Overview

- **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.

Highlights of Previous Courses



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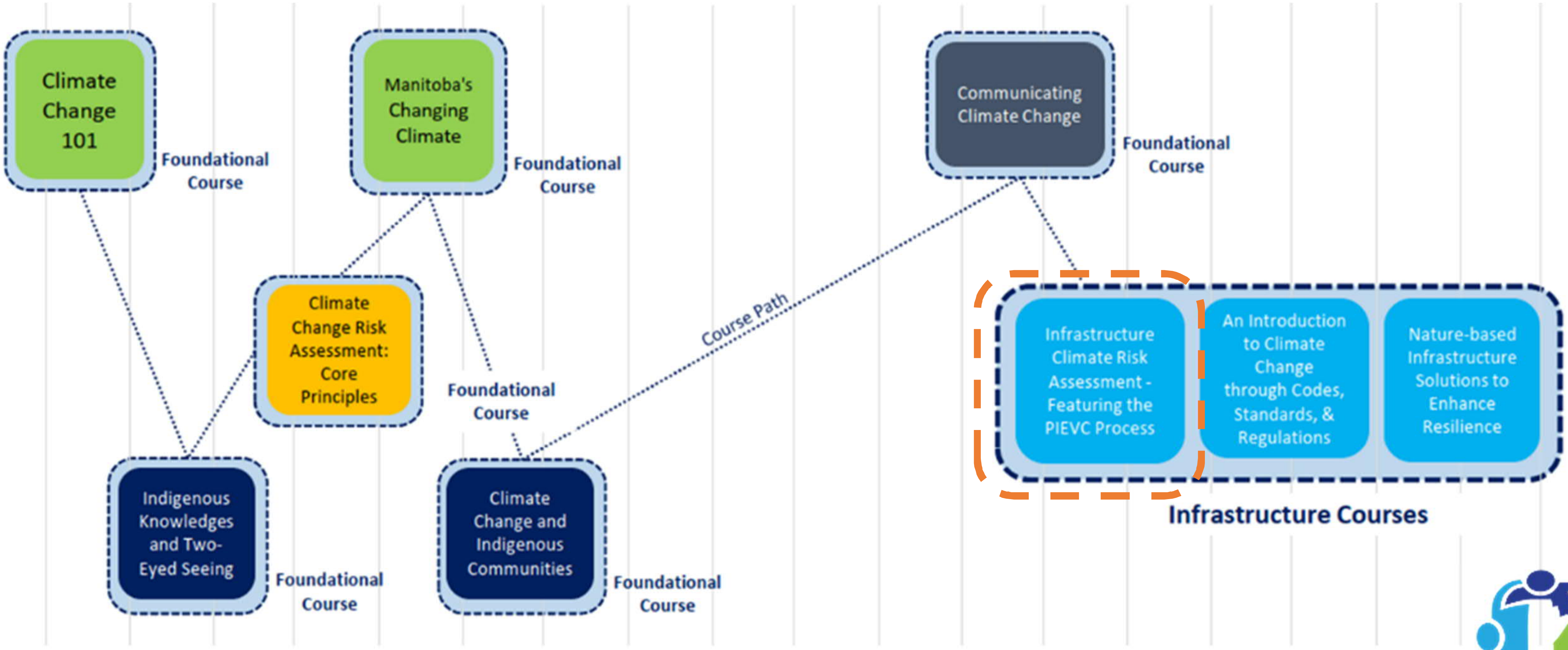
Highlights of Previous Courses



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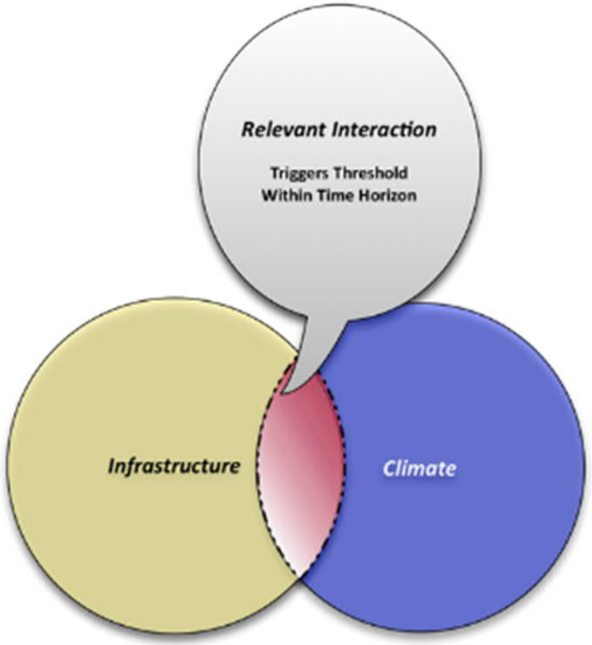
Climate Change Risk Assessment

- **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 on infrastructure planning, design, operation and management.



- **P**ublic **I**nfrastructure **E**ngineering **V**ulnerability **C**ommittee (Engineers Canada)

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

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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**
- **To be more sustainable and more resilient**

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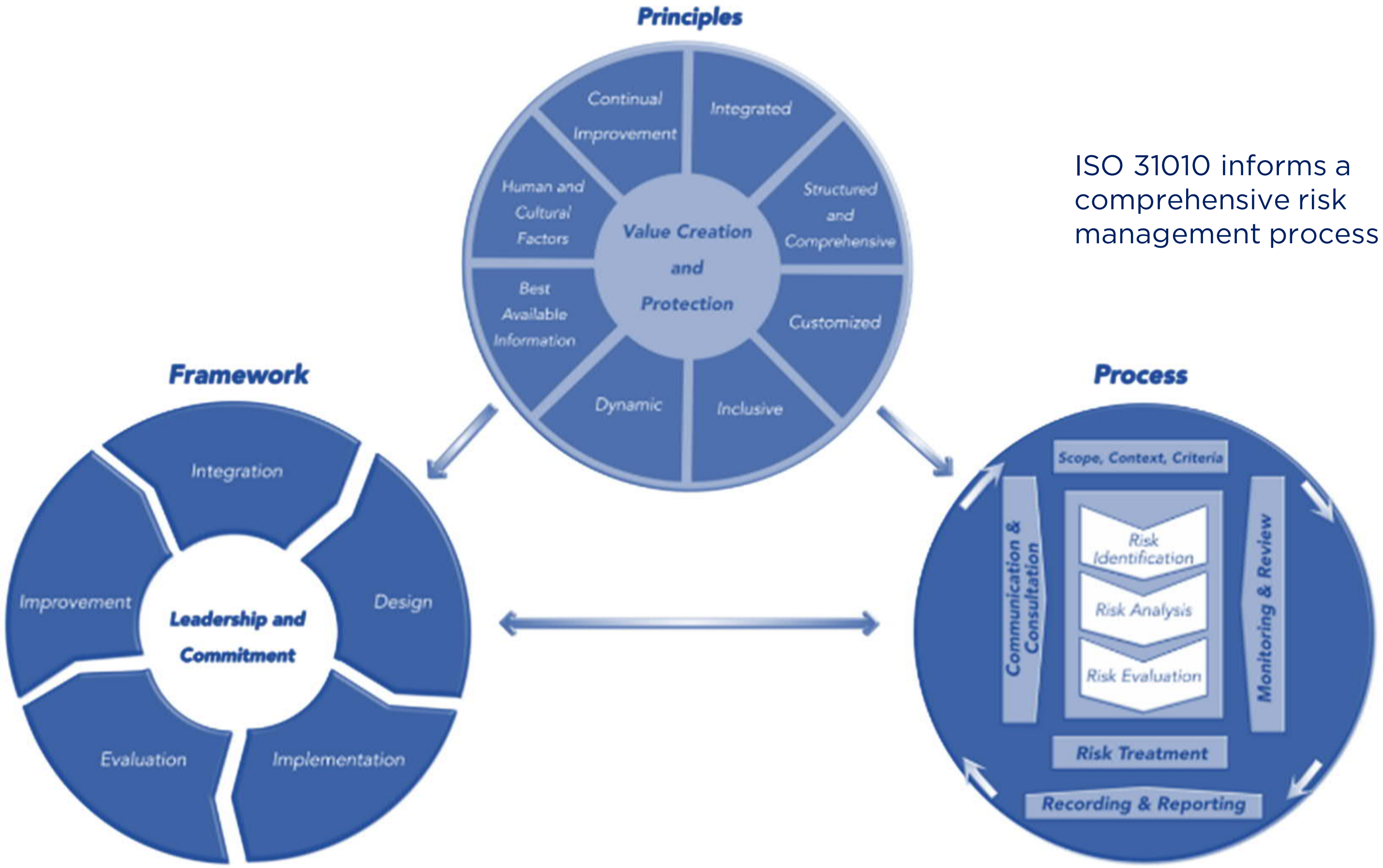
When to Assess Risk?

- Full lifecycle
  - Planning
  - Design
  - Operation
  - Upgrade



ISO 31010 informs a comprehensive risk management process

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When to Assess Risk?

- Full lifecycle
  - Planning
  - Design
  - Operation
  - Upgrade

	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

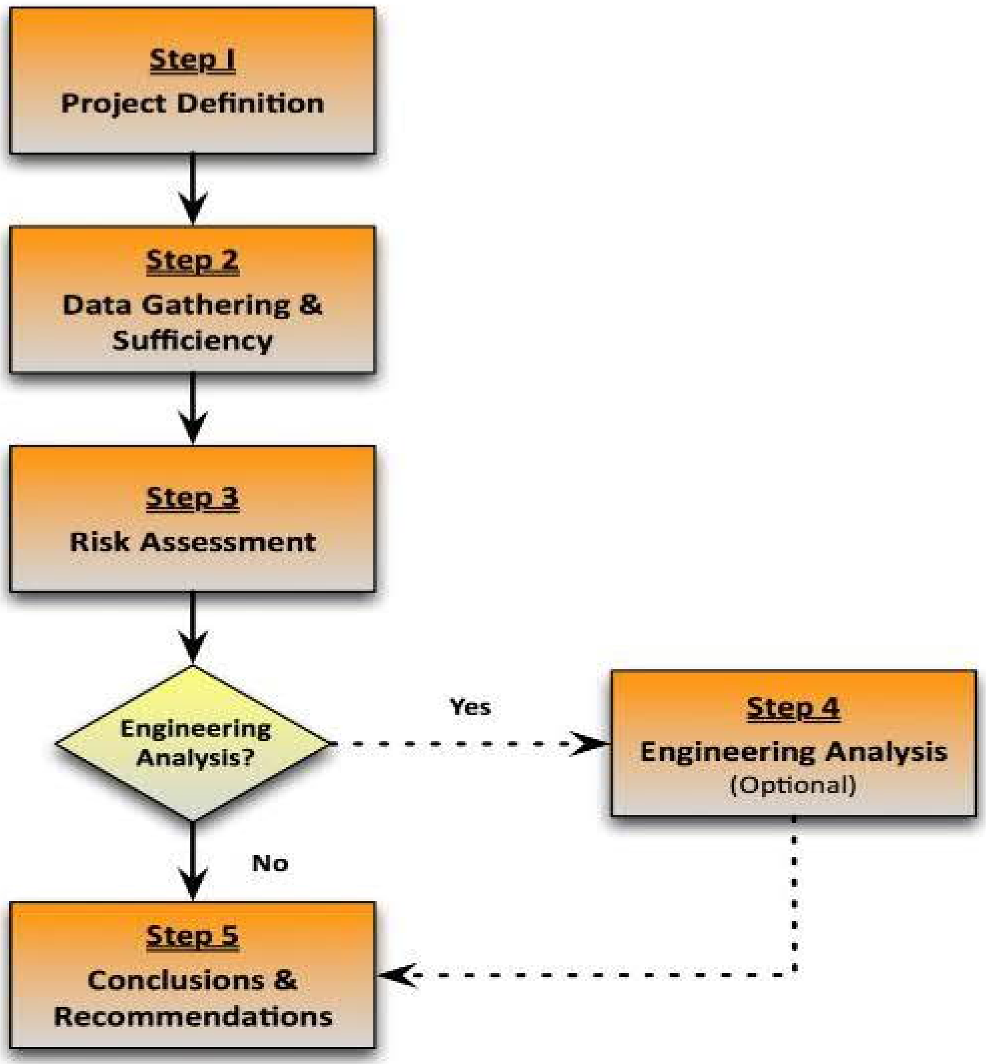
PIEVC Applications

- 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.

PIEVC 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



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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

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Example Project

- Highway 10 near the Town of Minnedosa

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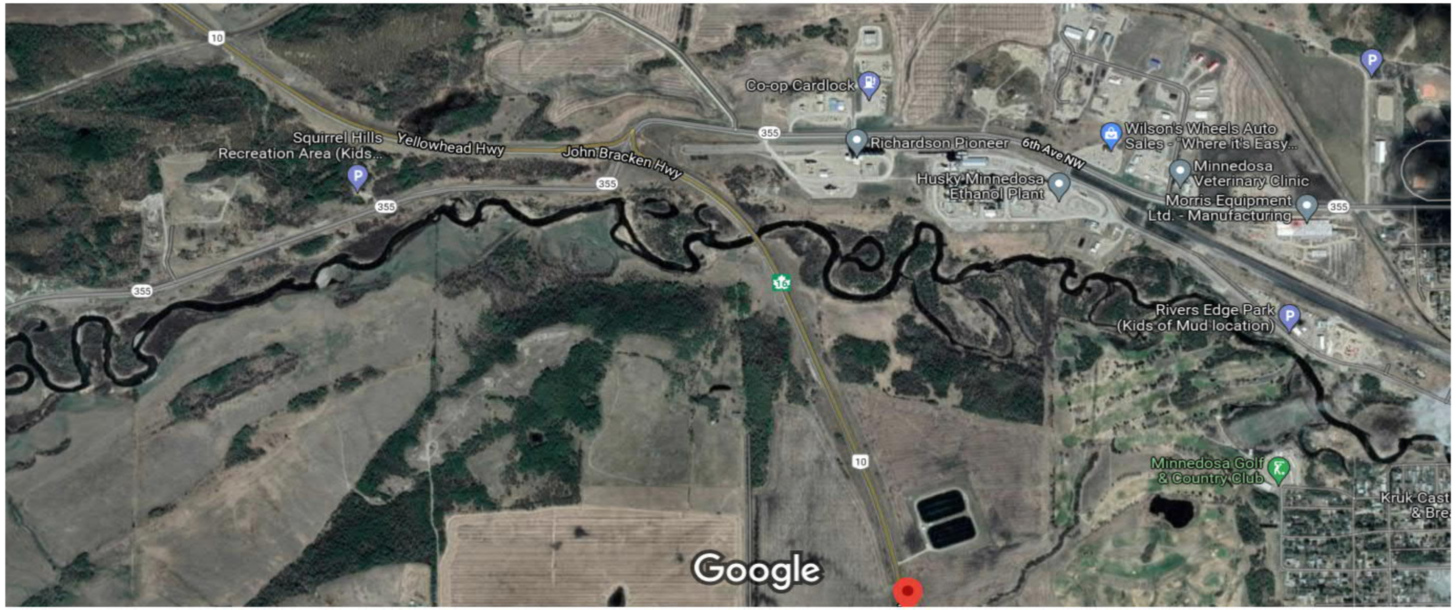
Example Project

- Highway 10 near the Town of Minnedosa

Google Maps MB-10

Highway 10



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Example Project

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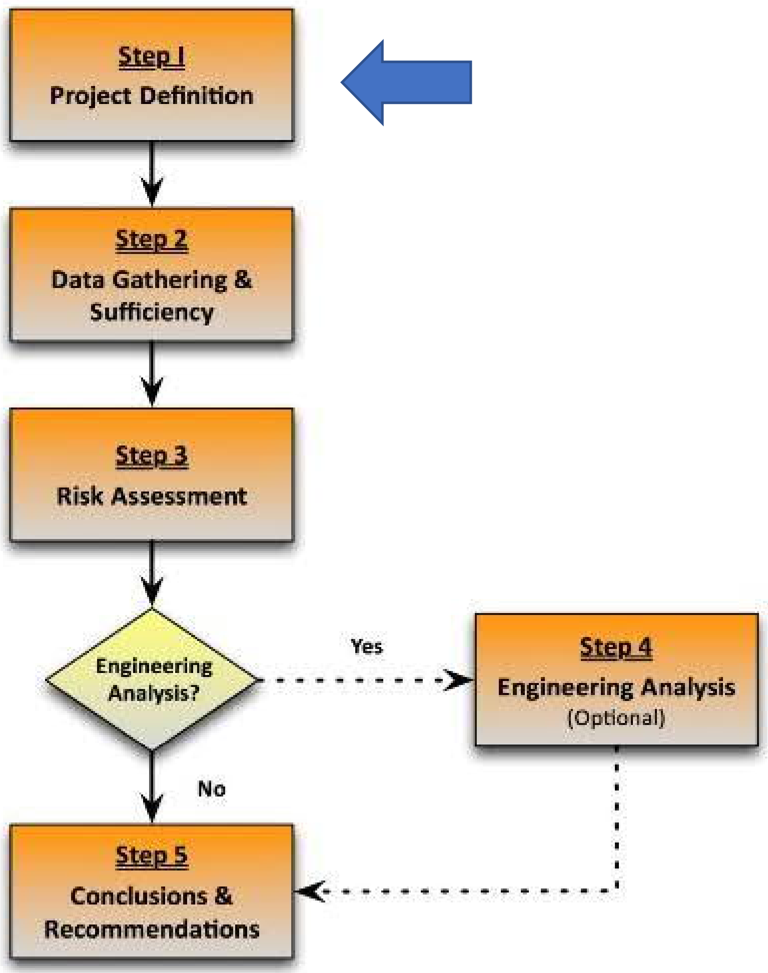
Example Project

Example Project Resources

- 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

- Establish
  - Infrastructure
  - Climate
  - Time Horizon
  - Geographical Setting
  - Applicable Jurisdictions



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Defining the Scope - Infrastructure

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

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Defining the Scope - Climate

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

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	Expected Lifecycle
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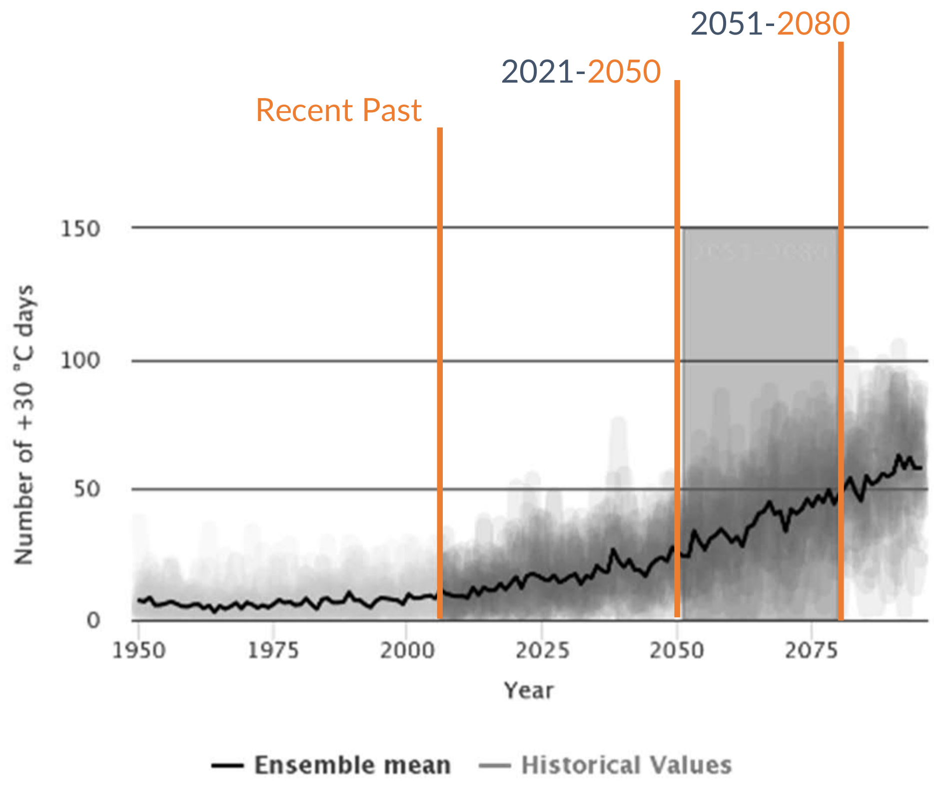

Defining the Scope - Geographical Setting and Jurisdictions

- Provincial
- Municipal
- Private

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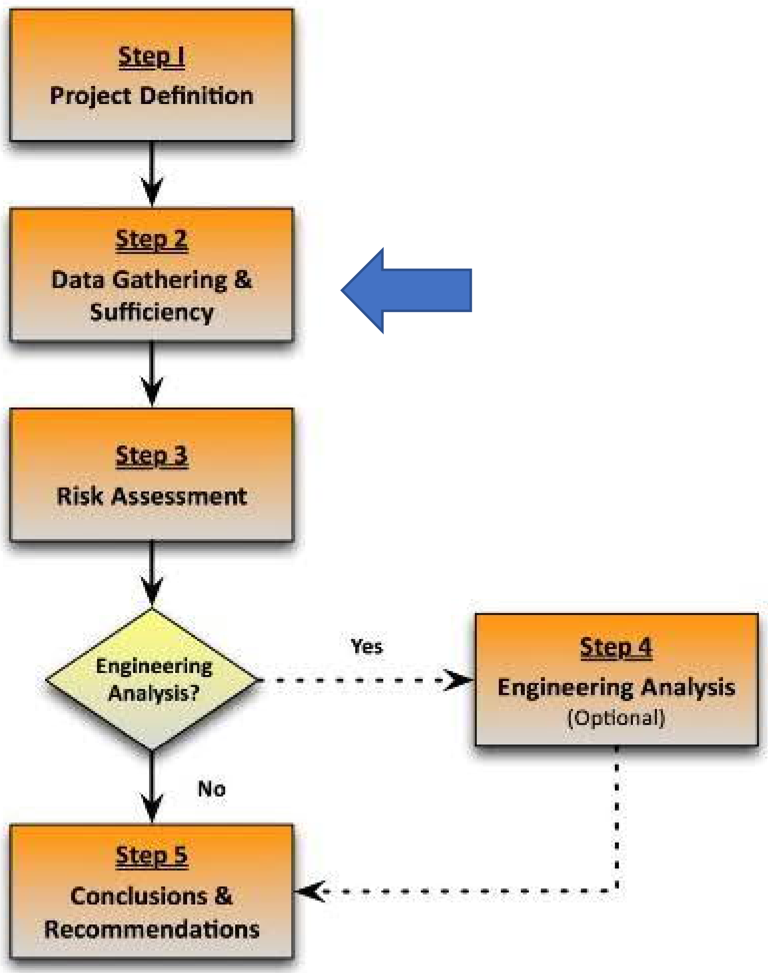
Defining Climate Data

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



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Defining Climate Data

- 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

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Defining Climate Data

- 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	480	376	511	646	375	513	696
Precipitation (mm)	spring	107	60	118	187	67	128	199
Precipitation (mm)	summer	208	121	211	313	110	201	308
Precipitation (mm)	fall	100	52	108	178	55	108	175
Precipitation (mm)	winter	68	45	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	18.7	17	19.9	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	-6.9
Tropical Nights	annual	0	0	1	5	0	6	20
Very hot days (+30 °C)	annual	7	5	19	38	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. 5	Sep. 28	Oct. 18	Sep. 20	Oct. 3	Oct. 28
Frost-Free Season (days)	annual	116	109	135	160	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	378	508	651	383	508	653
Precipitation (mm)	spring	107	60	118	189	62	119	195
Precipitation (mm)	summer	208	124	208	308	118	204	308
Precipitation (mm)	fall	100	54	107	174	53	108	172
Precipitation (mm)	winter	68	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	6.6	1.5	4.5	7.7
Mean Temperature (°C)	summer	18.7	16.7	19.5	20.3	17.5	19.8	21.7
Mean Temperature (°C)	fall	3	3.8	5	7.1	3.6	6	8.2
Mean Temperature (°C)	winter	-15.8	-17.1	-13.7	-9.7	-15.3	-11.8	-7.8
Tropical Nights	annual	0	0	1	4	0	3	8
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 23	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	103	131	155	111	138	168

Defining Climate Data

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
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Assigning Likelihood Scores

RCP 8.5: High Carbon climate future

GHG emissions continue to increase at current rates

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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

Score	Likelihood		
	Method A	Method B	Method C
0	Negligible Not Applicable	< 1 in 1,000	
1	Highly Unlikely Improbable	1 in 100	Likely to occur less frequently than current climate
2	Remotely Possible	1 in 20	
3	Possible Occasional	1 in 10	Likely to occur as frequently as current climate
4	Somewhat Likely Normal	1 in 5	
5	Likely Frequent	> 1 in 2.5	Likely to occur more frequently than current climate

Assigning Likelihood Scores

	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

Assigning Likelihood Scores

	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

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Assigning Likelihood Scores

	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

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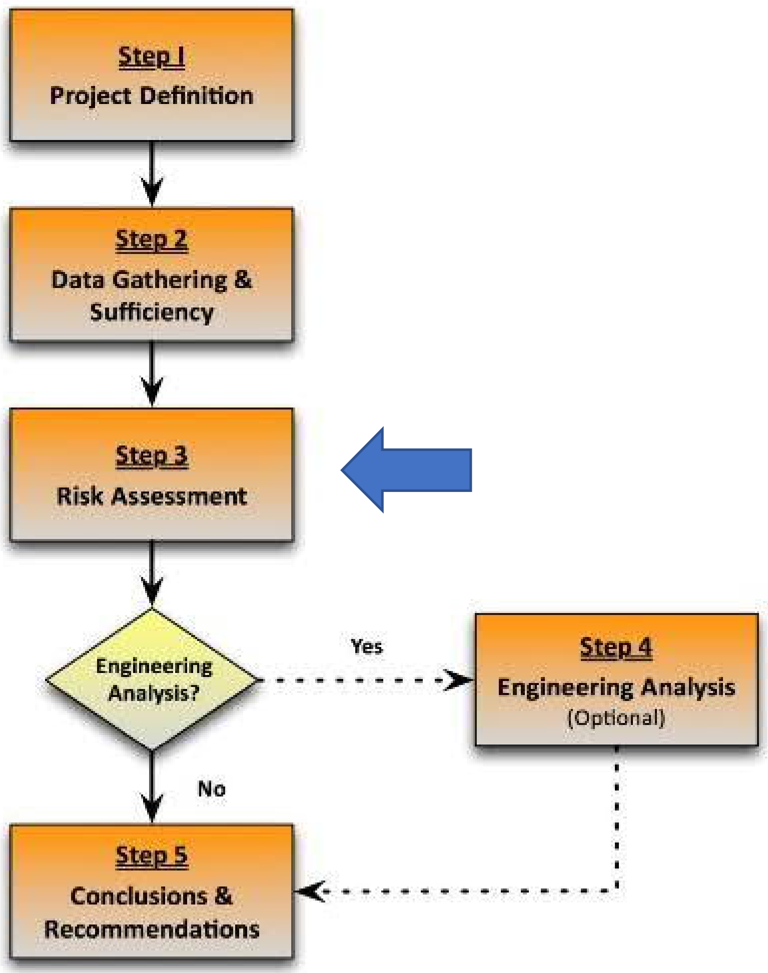
Assessing Risk

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



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Assessing Risk

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

- R = 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

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Assessing Risk

- Risk Assessment Worksheet

Climate Parameters

Infrastructure Components

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																									
1 Pavement Structure	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
2 Embankments	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																									
3 Culverts	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
4 Ditches	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																									
5 Maintenance	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
6 Guardrails	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
7 Signage	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																							
		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			
Climate Projections (Climate Atlas - RCP 8.5)	Present	444	3			51	3			1.8	3			238.9	3			83	3				3		
	2050	470	4			54	3			2.1	4			238.2	3			90	4			+	4		
	2080	498	5			57	3			2.3	4			238.1	3			96	4			+	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
Highway																									
Road																									
1 Pavement Structure	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		5		0		3		0		4		0		3		0		4		0		5		0
2 Embankments	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		5		0		3		0		4		0		3		0		4		0		5		0
Drainage																									
3 Culverts	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		5		0		3		0		4		0		3		0		4		0		5		0
4 Ditches	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		5		0		3		0		4		0		3		0		4		0		5		0
Highway Safety																									
5 Maintenance	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		5		0		3		0		4		0		3		0		4		0		5		0
6 Guardrails	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		5		0		3		0		4		0		3		0		4		0		5		0
7 Signage	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		5		0		3		0		4		0		3		0		4		0		5		0
Bridge																									

		Extreme Event									
		Extreme Winds				Lightning				Fl	
		Tornado				Lightning				Flood Ri / Ice	
Climate Projections (Climate Atlas - RCP 8.5)	Present		3				3				3
	2050	+	4			+	4			+	4
	2080	+	5			+	5			+	5
Infrastructure Components		Y/N	L	C	R	Y/N	L	C	R	Y/N	L
Highway											
Road											
1 Pavement Structure	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
2 Embankments	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
Drainage											
3 Culverts	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
4 Ditches	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
Highway Safety											
5 Maintenance	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
6 Guardrails	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
7 Signage	Present		3		0		3		0		3
	2050		4		0		4		0		4
	2080		5		0		5		0		5
Bridge											

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MANITOBA CLIMATE RESILIENCE TRAINING

Assessing Risk

- 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 (Y / N)
  - Evaluate the consequence of the climate interaction. Assign a Consequence Score (C)
  - Review risk assessment results and discuss how the risks could be addressed

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MANITOBA CLIMATE RESILIENCE TRAINING

Assessing Risk

- Risk Assessment (Workshop)
  - Evaluate if a given infrastructure component will interact with a given climate parameter (Yes / No)
  - 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

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MANITOBA CLIMATE RESILIENCE TRAINING

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Assessing Risk

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			
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		
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	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
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																									
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
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																									
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
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
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																									
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
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
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)			
Climate Projections (Climate Atlas - RCP 8.5)	Present	480	3			56	3			3	3			245.6	3			66	3		
	2050	511	4			61	3			3.5	4			244.7	3			73	4		
	2080	513	4			61	3			3.4	4			245.8	3			79	4		
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
Highway																					
Road																					
Pavement Structure	Present		3		6		3		9		3		12		3		9		3		9
	2050	Y	4	2	8	Y	3	3	9	Y	4	4	16	Y	3	3	9	Y	4	3	12
	2080		4		8		3		9		4		16		3		9		4		12
Embankments	Present		3		9		3		12		3		12		3		9		3		9
	2050	y	4	3	12	y	3	4	12	y	4	4	16	y	3	3	9	y	4	3	12
	2080		4		12		3		12		4		16		3		9		4		12
Drainage																					
Culverts	Present		3		6		3		12		3		12		3		6		3		9
	2050	y	4	2	8	y	3	4	12	y	4	4	16	y	3	2	6	y	4	3	12
	2080		4		8		3		12		4		16		3		6		4		12
Ditches	Present		3		6		3		12		3		12		3		6		3		9
	2050	y	4	2	8	y	3	4	12	y	4	4	16	y	3	2	6	y	4	3	12
	2080		4		8		3		12		4		16		3		6		4		12
Highway Safety																					
Maintenance	Present		3		0		3		9		3		12		3		6		3		9
	2050		4		0	y	3	3	9	y	4	4	16	y	3	2	6	y	4	3	12
	2080		4		0		3		9		4		16		3		6		4		12
Guardrails	Present		3		0		3		0		3		9		3		0		3		9
	2050		4		0		3		0	y	4	3	12		3		0	y	4	3	12
	2080		4		0		3		0		4		12		3		0		4		12
Signage	Present		3		0		3		0		3		9		3		0		3		12
	2050		4		0		3		0	y	4	3	12		3		0	y	4	4	16
	2080		4		0		3		0		4		12		3		0		4		16
Bridge																					
Bridge																					
Bridge Substructure / Foundation	Present		3		0		3		0		3		0		3		0		3		0
	2050		4		0		3		0		4		0		3		0		4		0
	2080		4		0		3		0		4		0		3		0		4		0
Bridge Superstructure	Present		3		0		3		9		3		12		3		0		3		9
	2050		4		0	y	3	3	9	y	4	4	16		3		0	y	4	3	12
	2080		4		0		3		9		4		16		3		0		4		12
Bridge Deck	Present		3		0		3		9		3		12		3		0		3		9
	2050		4		0	y	3	3	9	y	4	4	16		3		0	y	4	3	12
	2080		4		0		3		9		4		16		3		0		4		12

Extreme Events

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

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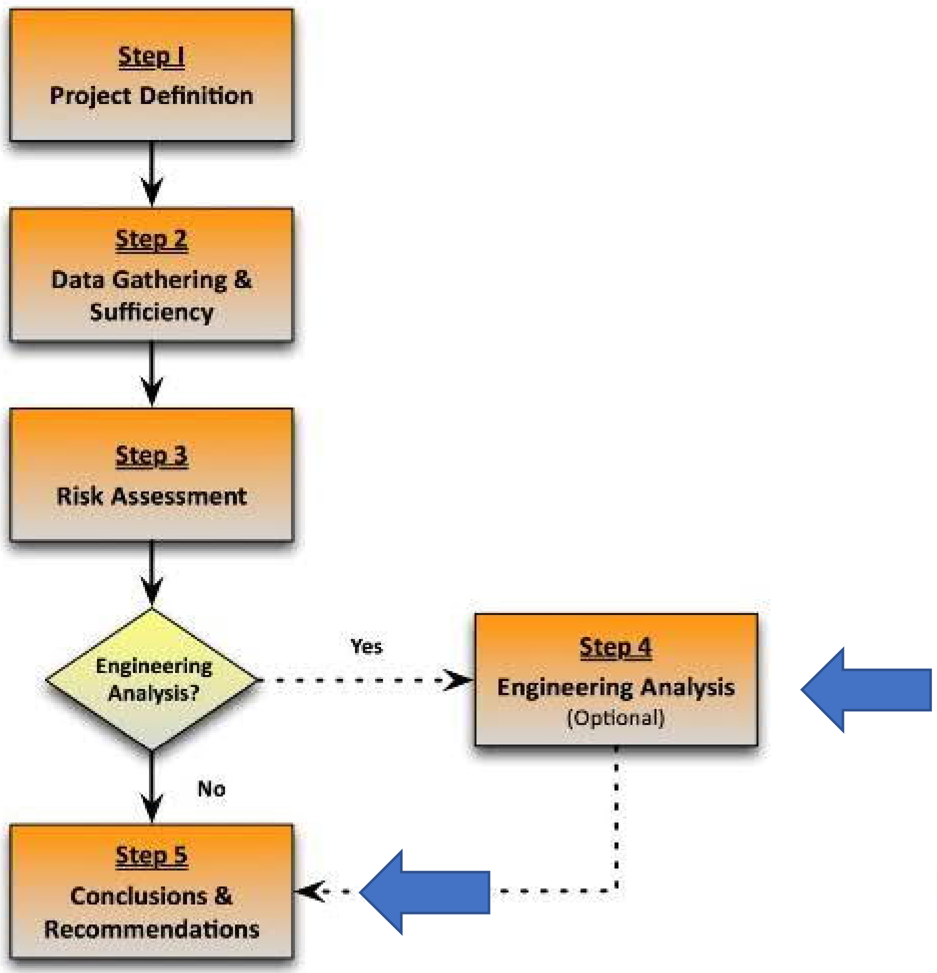
MANITOBA CLIMATE RESILIENCE TRAINING

Risk Evaluation and Treatment

- Engineering Analysis
  - Optional

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



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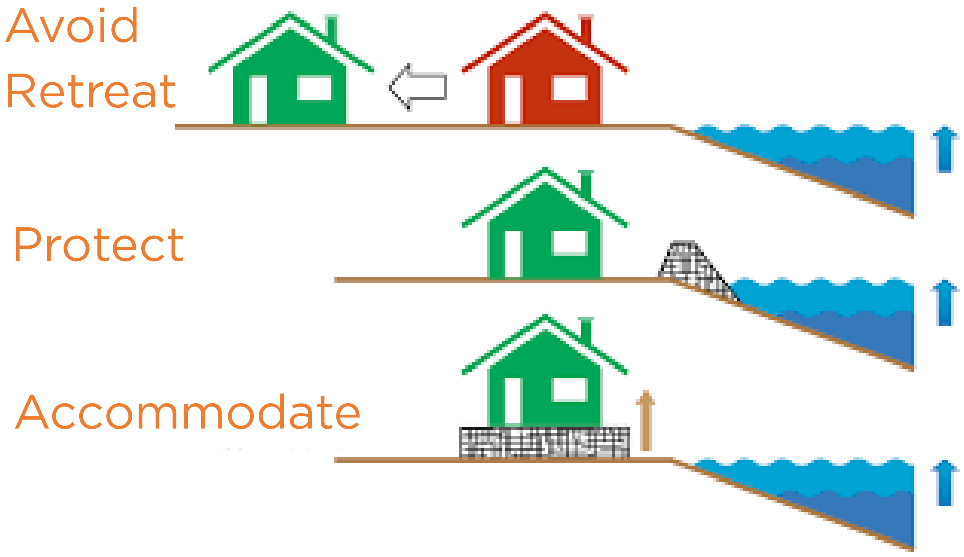
Risk Evaluation and Treatment

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



Risk Evaluation and Treatment

- Example Project

	Comments	Risk Action Remedial Action Management Action No Further Action 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.

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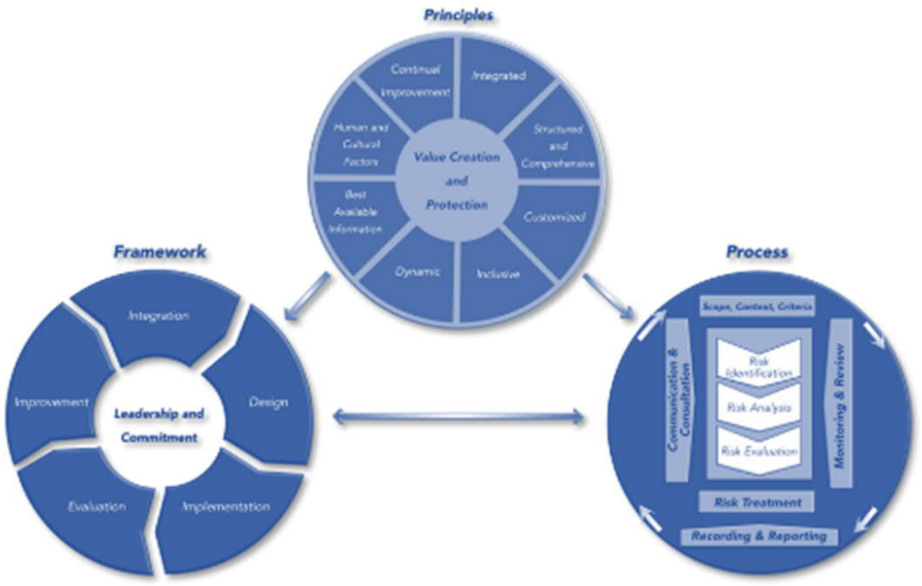
MANITOBA CLIMATE RESILIENCE TRAINING

Risk Evaluation and Treatment

- Next Steps:
  - Further risk assessment on high and medium risk
  - 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
  - Inform infrastructure upgrades on areas to adapt
  - Inform adaptation plans



Risk Evaluation and Treatment

- Communication
  - Reporting / Presentations / Workshops / Stakeholder Engagement
  - Decision Making (Context)
  - Financial case study
  - Cost benefit analysis
  - Triple Bottom Line analysis
  - Opportunities to integrate sustainable infrastructure

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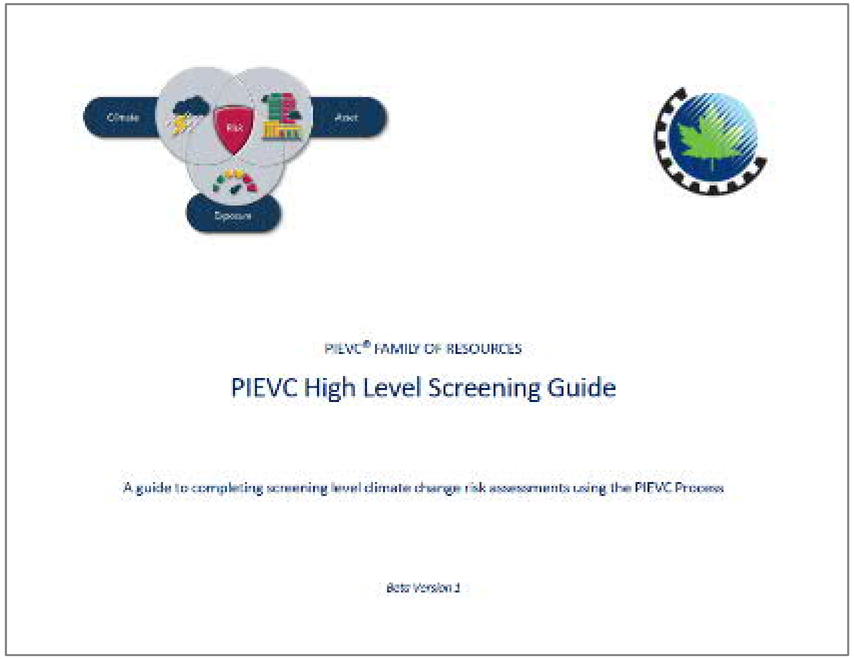
PIEVC High Level Screening Guide

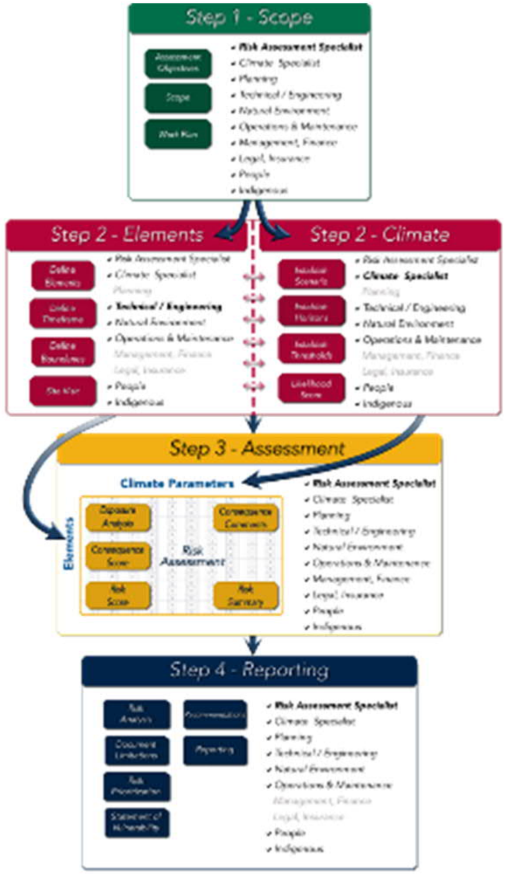


PIEVC® FAMILY OF RESOURCES

PIEVC High Level Screening Guide

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

Beta Version 1



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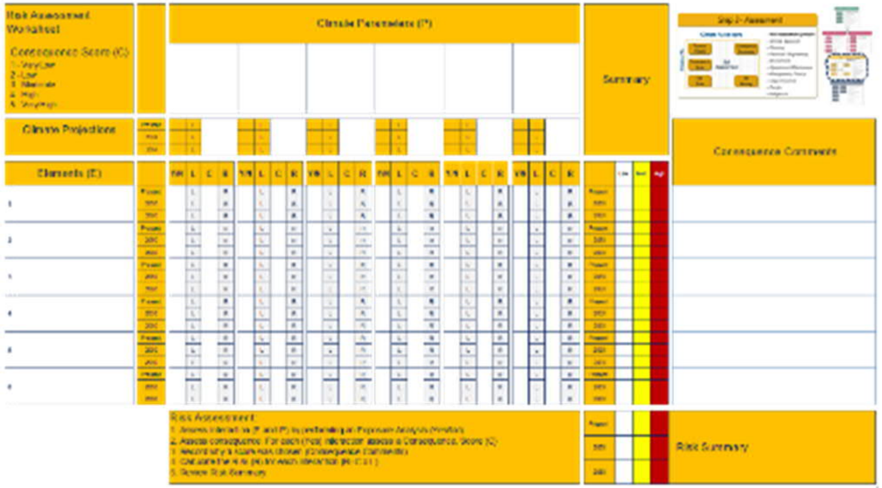
Asset	Elements	Sub Elements	Parameters	Hazards for Consideration
Water Supply System	Water Supply Intake	Intake structure	Temperature	Extreme Heat Extreme Cold Heat Wave Cold Snap
		Raw Water Pump Stations		
	Water Treatment Plant Building - Structural	Envelope		
		Roofing		
		Foundation	Precipitation	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		

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	58.8	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 EF 1 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



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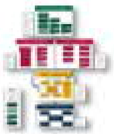
Appendix - Example Projects

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 IPIC 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

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

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

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 rainfall
Freezing conditions	High winds
High intensity short duration rains	Fires

Summary

- Next Infrastructure Courses

AN INTRODUCTION TO CLIMATE CHANGE THROUGH CODES, STANDARDS, AND REGULATIONS

We now know that a stable, reliable climate system is no longer something that can be counted on. Learn how codes, standards, and regulations are changing to ensure that our new infrastructure is best prepared for climate changes now and in future.

- Recommended prerequisite: Climate Change 101
- Week of February 7, 2022
- 90min
- Virtual
- Presented by Engineers Geoscientists Manitoba

NATURE-BASED INFRASTRUCTURE SOLUTIONS TO ENHANCE RESILIENCE

Natural infrastructure is becoming a mainstream option for enhancing the resilience of built infrastructure and communities. This course will provide a basic understanding using sustainable / natural infrastructure / innovative solutions to build resilience to climate change. A diverse range of nature-based solutions, implementation considerations, and their co-benefits will be presented

- Recommended prerequisites: Climate Change 101, Manitoba's Changing Climate, Climate Risk Assessment Core Principles, Climate Risk Assessment using PIEVC, Codes, Standards and Regulations
- Week of February 21, 2022
- 90 min
- Virtual
- Presented by Engineers Geoscientists Manitoba

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Questions

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