

Conducting a Climate Change Resilience Assessment in Support of Remedy Selection

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Agenda

- Why are we talking about this
- Project Overview
- Methodology
- Results
- Conclusions



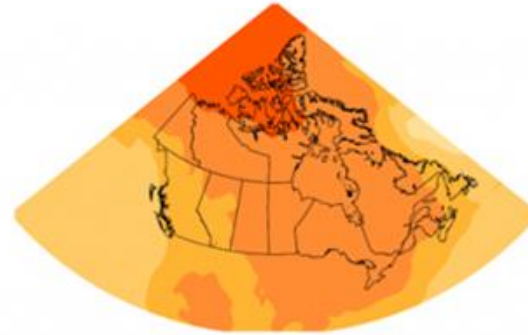
<https://arctic-council.org/>
2020 photo credit GBP Creative

Climate Change in Canada

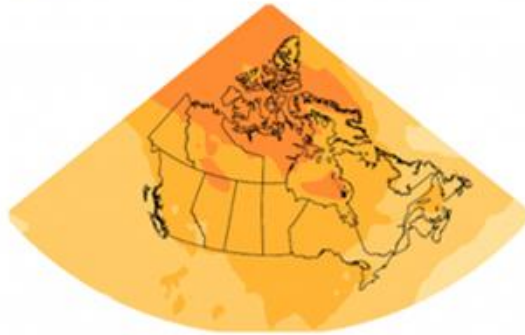
a) Temperature change RCP2.6 (2031–2050)
Annual



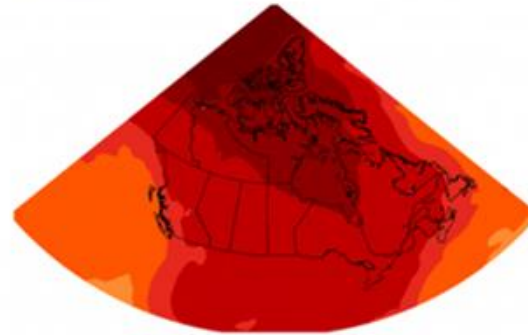
b) Temperature change RCP8.5 (2031–2050)
Annual



c) Temperature change RCP2.6 (2081–2100)
Annual



d) Temperature change RCP8.5 (2081–2100)
Annual



Precipitation change RCP2.6 (2031–2050)
Annual



Precipitation change RCP8.5 (2031–2050)
Annual



Precipitation change RCP2.6 (2081–2100)
Annual



Precipitation change RCP8.5 (2081–2100)
Annual



Canada's Changing Climate Report

https://publications.gc.ca/collections/collection_2019/eccc/En4-368-2019-eng.pdf

Changes on the Land

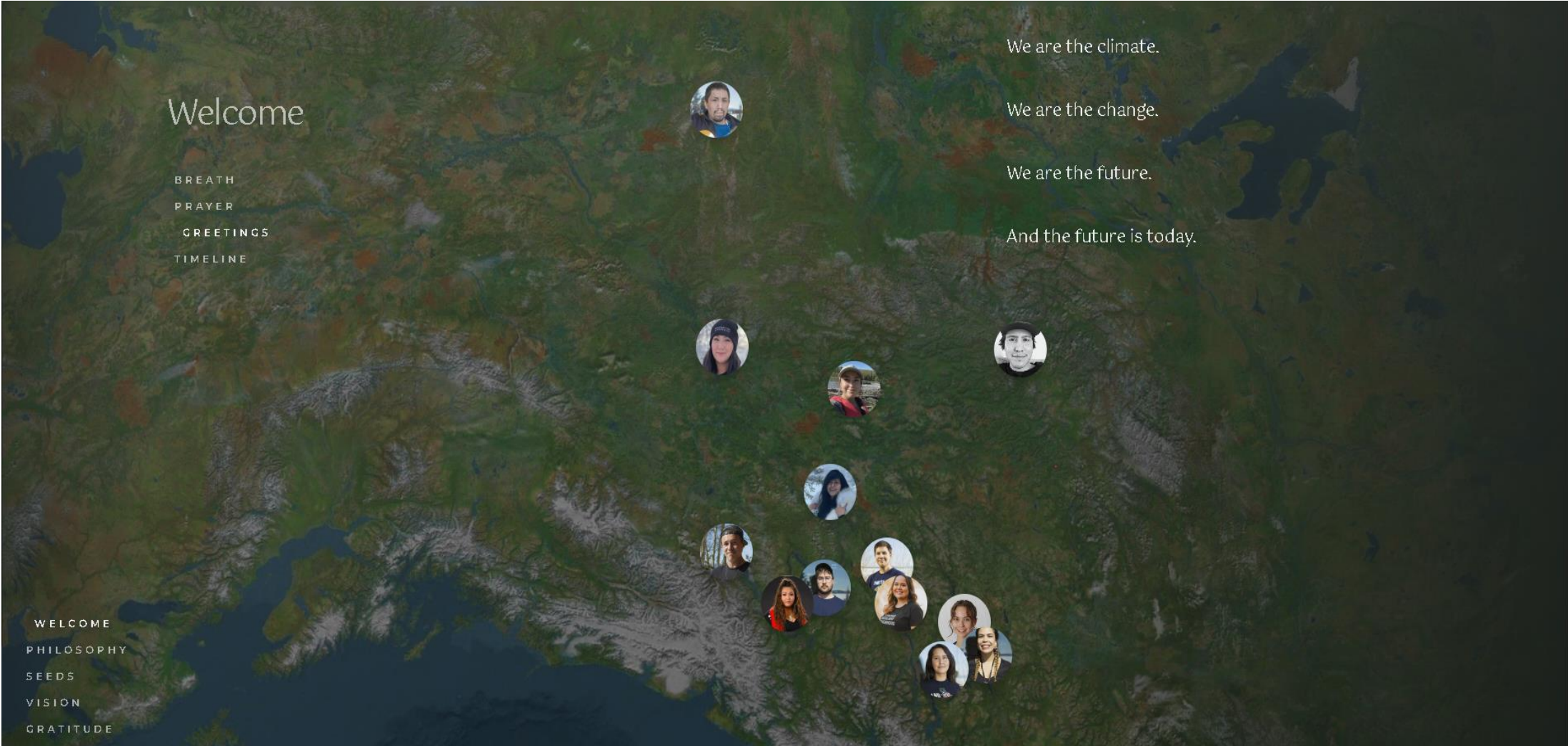


cbc.ca/photo submitted by Kevin Turner



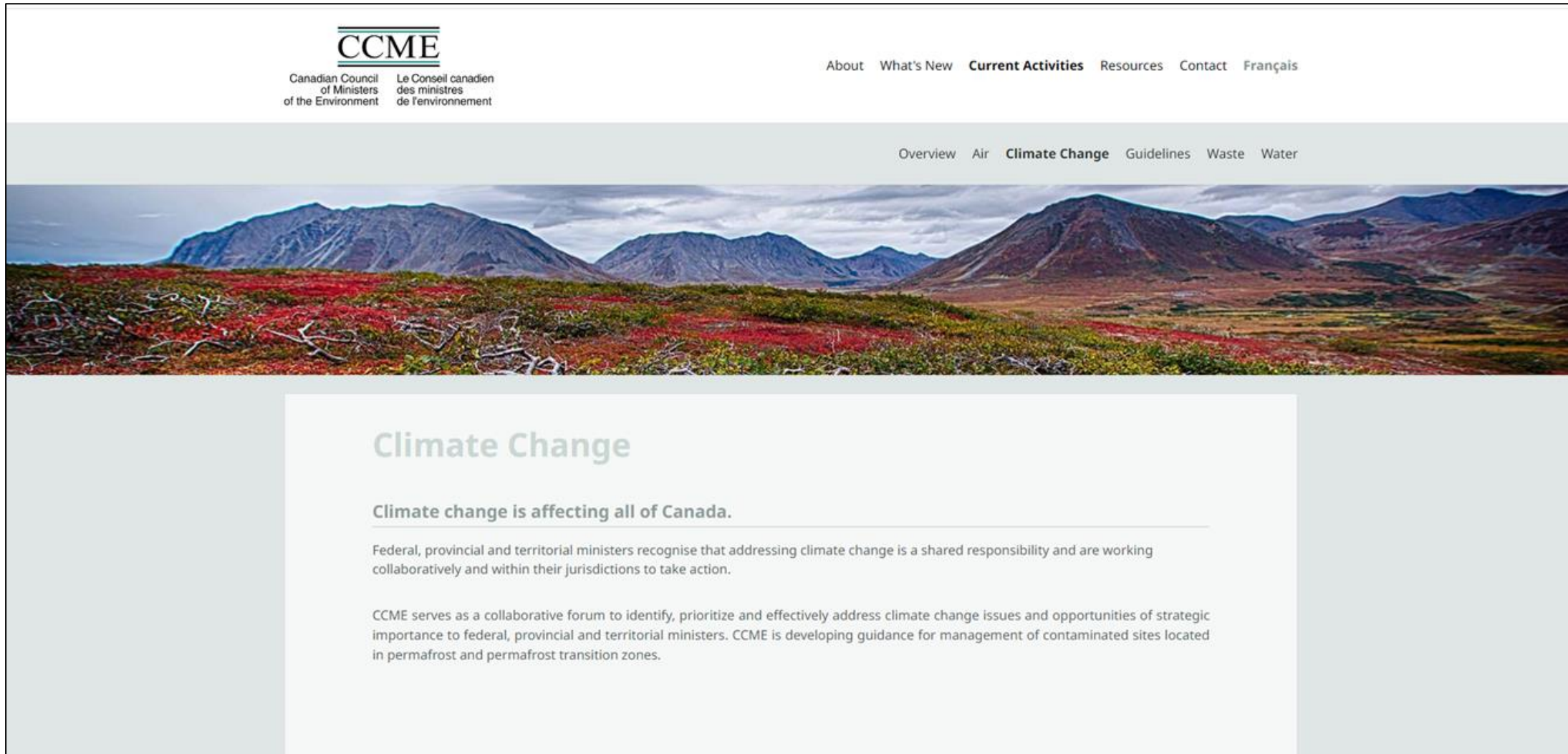
Yukon Protective Services/Facebook

Yukon First Nations Climate Change Emergency Declaration



Yukon First Nations Climate Action Fellowship (2023). Reconnection Vision. Yukon, Canada.

Canadian Council of Ministers of the Environment



The screenshot shows the CCME website header with the logo and navigation menu. The main content area features a large landscape image of mountains and tundra. Below the image, the 'Climate Change' section is highlighted, containing a sub-header, a key message, and a paragraph of text.

CCME
Canadian Council of Ministers of the Environment / Le Conseil canadien des ministres de l'environnement

About What's New **Current Activities** Resources Contact Français

Overview Air **Climate Change** Guidelines Waste Water

Climate Change

Climate change is affecting all of Canada.

Federal, provincial and territorial ministers recognise that addressing climate change is a shared responsibility and are working collaboratively and within their jurisdictions to take action.

CCME serves as a collaborative forum to identify, prioritize and effectively address climate change issues and opportunities of strategic importance to federal, provincial and territorial ministers. CCME is developing guidance for management of contaminated sites located in permafrost and permafrost transition zones.

Project Overview

- Location: Northern Yukon
- Site Geology:
 - Permafrost
 - Muskeg and kettle lakes
 - Inactive fluvial deposits
 - Underlain by approximately 30 m of stratified fine silt, clay, and sand
- Nature and Extent of Contamination:
 - Petroleum hydrocarbon (PHC) contamination in the soil and supra-permafrost water at multiple sites

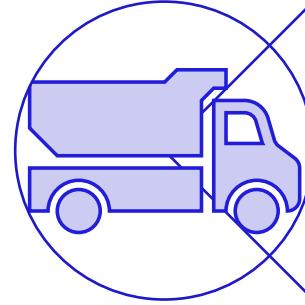


Photo credit Government of Yukon

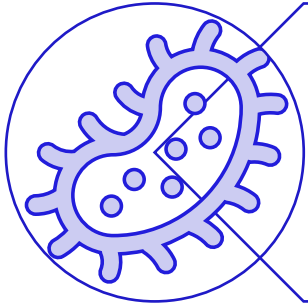
Remedial Options Assessment



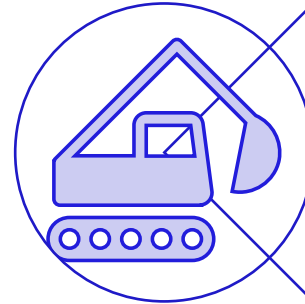
Natural Source Zone Depletion (NSZD) and Risk Management



Excavation and Transportation via Winter Road



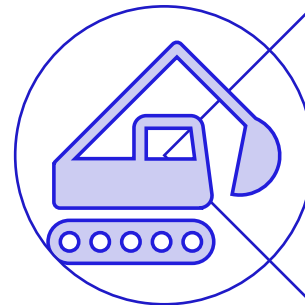
Enhanced In-Situ Bioremediation



Excavation and Land Treatment on a mountain plateau

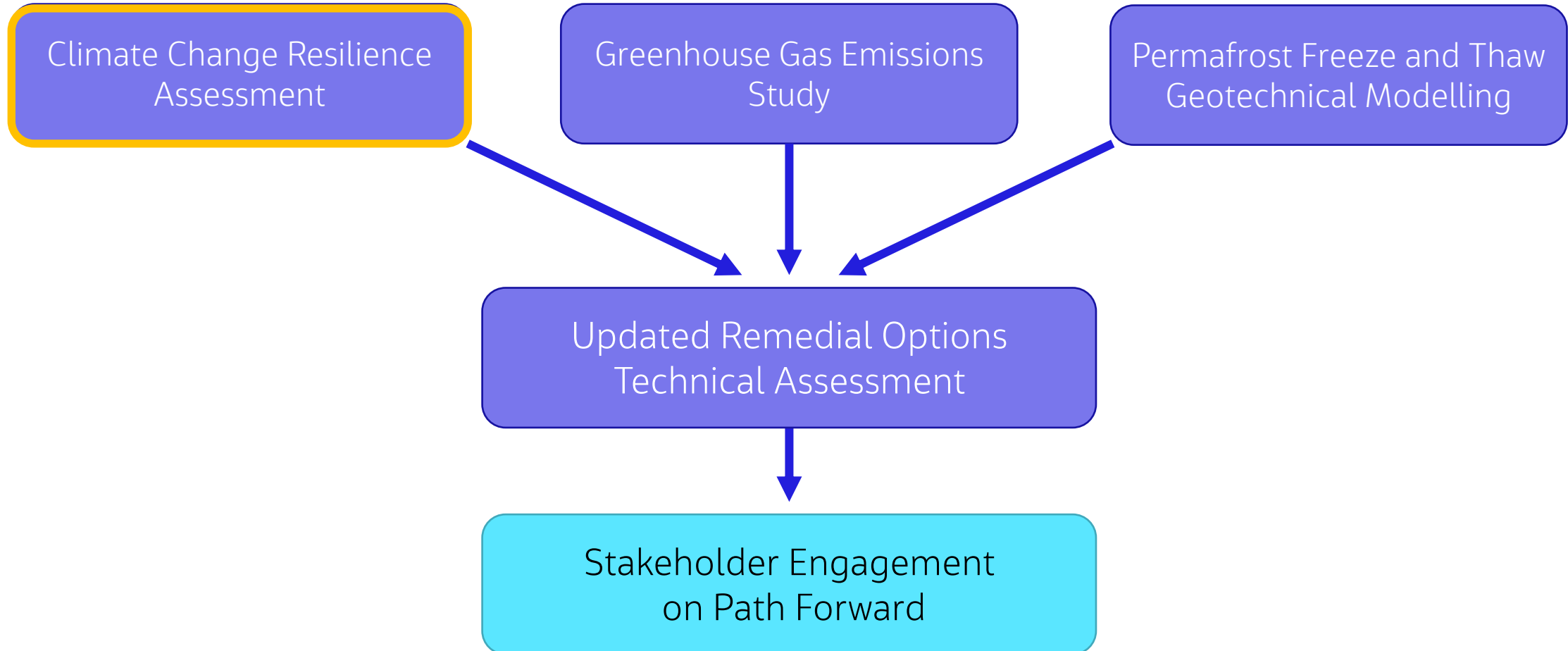


Excavation and Thermal Treatment



Excavation and Land Treatment on low lying lands

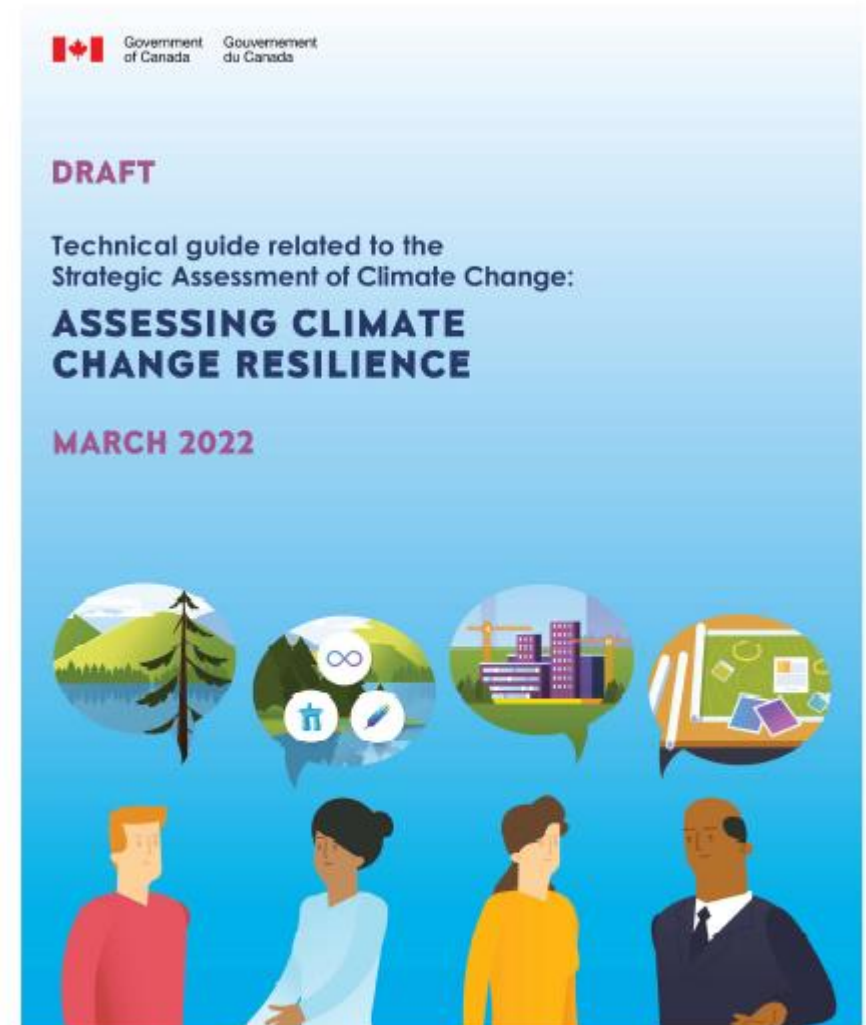
How will this information be used?



Climate Change Resilience Assessment




Climate Change Resilience
Assessment

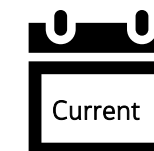
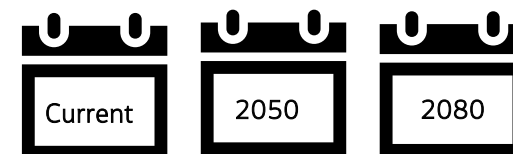
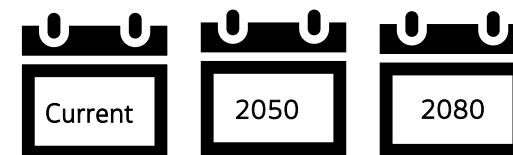
- Process: Comparable to PIEVC and ISO 31000
- Purpose: Identify and evaluate climate risks under the current climate (past 30 years) and predicted future scenarios by (2050 and 2080)



www.strategicasessmentclimatechange.ca/ 

Climate Events

		Climate Event	Trend
Temperature		Summer Mean Temperature (°C)	↑
		Winter Mean Temperature (°C)	↑
		Days Above 25°C	↑
		Day Below -25°C	↓
Precipitation		Annual Precipitation (mm)	↑
		Maximum 5 Consecutive Days (mm)	↑
		Maximum 1-day Precipitation (mm)	↑
		High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle)	↑
		Winter Precipitation (mm, water equivalent)	↑
Other (qualitative)		Flooding Frequency (Open-water and ice-jam)	?
		Landslide	?
		Permafrost Thaw (temperature)	↑



Methodology

Risk Rating Heat Map

Consequence Rating	Critical	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
Likelihood Rating							

Methodology

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	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
Likelihood Rating							

Improbable	Not likely to occur in the period
Remote	Likely to occur once between 30 and 50 years
Occasional	Likely to occur once between 10 and 30 years
Probably	Likely to occur at least once a decade
Frequent	Likely to occur once or more annually

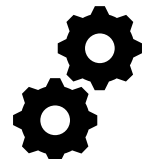
Methodology

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Safety



Efficacy



Environment




Methodology

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Likelihood Rating							

Risk Classification	Rating	Recommended Risk Treatment (Adaptation)
Low (No Colour)	1-9	No action necessary
Medium (Yellow)	10-19	Action may be required
High (Red)	20-25	Action required

An example

-  Remedy: Excavation and Transportation via Winter Road
-  Time Horizon: Current
-  Climate Event: Increasing Summer Mean Temperature

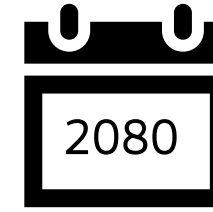
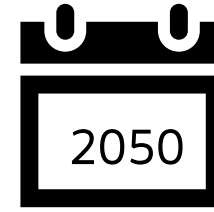
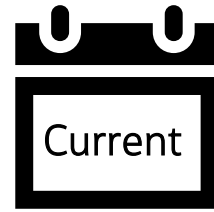
Risk Rating Heat Map




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			1	2	3	4	5
			Improbable	Remote	Occasional	Probable	Frequent
Likelihood Rating							

Potential Consequences	Identified Adaptation Measures
Increase permafrost impacts caused by excavation	Insulate the open excavation to limit permafrost thaw
Thawing permafrost impacts sidewall stability	
Thawing permafrost may increase dewatering requirement	



Excavation and
Transportation via Winter
Road

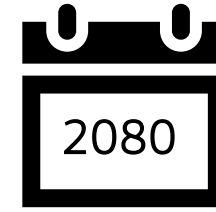
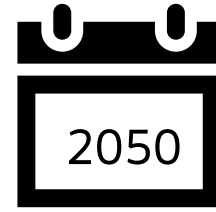
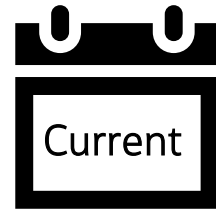





	Current	2050	2080
 Summer Mean Temperature (°C) Winter Mean Temperature (°C) Days Above 25 °C Day Below -25 °C	15	15	15
	5	5	5
	15	15	15
	5	5	4
 Annual Precipitation (mm) Maximum 5 Consecutive Days (mm) Maximum 1-day Precipitation (mm) High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle) Winter Precipitation (mm, water equivalent)	4	4	4
	8	8	8
	8	8	8
	5	5	10
	20	25	25
 Flooding Frequency (Open-water and ice-jam) Landslide Permafrost Thaw (temperature)	High (25)		
	Low (9)		
	High (25)		

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NSZD and Risk Management



	Current	2050	2080	
	Summer Mean Temperature (°C)	10	10	10
	Winter Mean Temperature (°C)	15	15	15
	Days Above 25 °C	5	5	5
	Day Below -25 °C	15	15	12
	Annual Precipitation (mm)	12	12	12
	Maximum 5 Consecutive Days (mm)	12	12	12
	Maximum 1-day Precipitation (mm)	12	12	12
	High Intensity, High Volume Rain Storm (mm in 1 hour in 100 year cycle)	2	2	2
	Winter Precipitation (mm, water equivalent)	4	5	5
	Flooding Frequency (Open-water and ice-jam)	Low (9)		
	Landslide	Low (9)		
	Permafrost Thaw (temperature)	Low (9)		

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Overall Resiliency Rankings

Overall Risk Rating	Climate Resiliency Rating
30-240	High Resiliency
241-480	Moderate Resiliency
481-750	Low Resiliency

Remedial Option	Overall Risk Rating (0 to 750)	Climate Resiliency Rating
In-situ Bio-remediation	187	High Resiliency
NSZD	278	Moderate Resiliency
Excavation and Thermal Treatment	280	Moderate Resiliency
Excavation and Transportation out of Old Crow	328	Moderate Resiliency
Excavation and Land Treatment on Mountain Plateau	382	Moderate Resiliency
Excavation and Land Treatment on Low Lying Lands	418	Moderate Resiliency

Conclusions

- Increased challenges, risks and costs with the acceleration of climate change.
- Proactively planning for climate change is key for:
 - Identifying project challenges and risks;
 - Implementing adaptation measures and mitigation strategies;
 - Protecting human health and the environment;
 - Cost savings.
- Stakeholder engagement helps inform the project.



utoronto.ca

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RemTech 2023

Banff, AB | October 11-13, 2023
Visit booth No. 26

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Kendra Waltermire
Senior Environmental Remediation Engineer

Lindsay Shaw
Geologist

Tom Palaia
Principal Technologist



Climate References

- Climate Data Canada (ECCC 2023a)
- Climate Atlas of Canada, Climate Atlas Report (Climate Atlas of Canada 2022)
- Landscape Hazards (Benkert et al. 2016)
- Exposure analysis and risk reduction recommendations (Turcotte and Saal 2022)
- Project Planning Guidelines for Permafrost Management (Morrison Hershfield 2022)
- Design and Implementation of Early Detection and Warning Systems for Transportation Infrastructure impacted by permafrost-related geohazards (Calmels et al. 2022)