Applying the Climate Lens Resilience Assessment in a BC Context

FBC Presentation
Dirk Nyland, P.Eng., IRP,
Chief Engineer, BCMoTI

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BRITISH COLUMBIA
Ministry of Transportation and Infrastructure

There has been a substantial increase in the intensity of heavy-precipitation events over large parts of the Northern Hemisphere due to greenhouse gases.

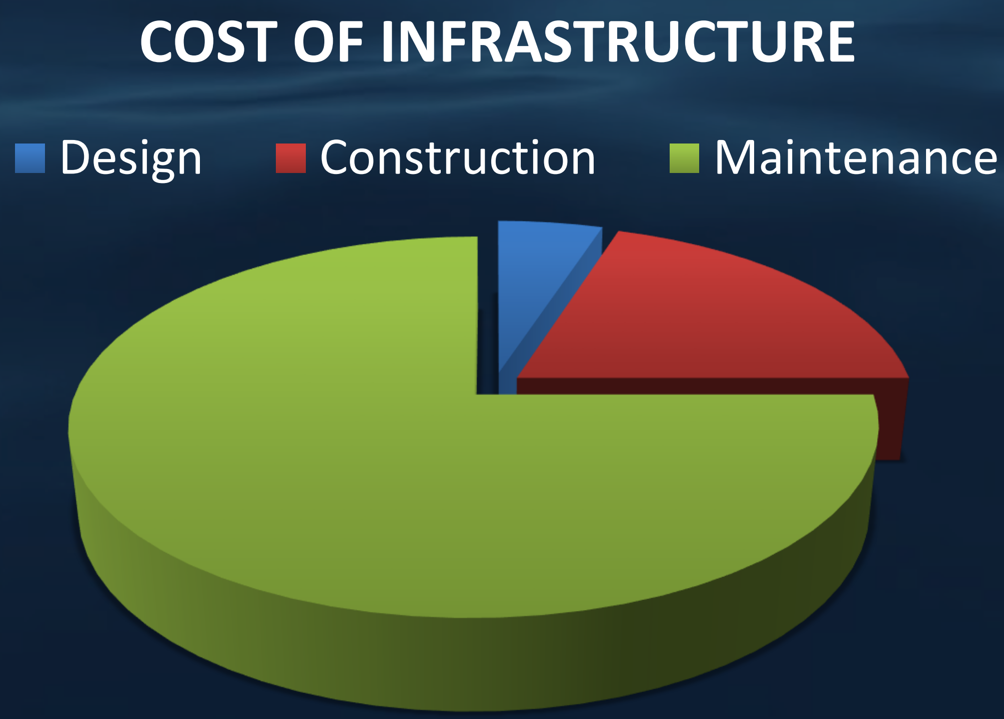
(Storms with over 100 millimetres of precipitation in 24 hours.)

Source: Zwiers, Nature, 2011

Holberg Road (Vancouver Island, Sept 2010)

Hagensborg (Bella Coola, Sept 2010)

Goal is to reduce damage from extreme weather events and climate changes by **adapting** engineering design and practices for resilient, reliable, efficient and effective transportation infrastructure



(resilience = lower maintenance)

BCMoTI involved developing PIEVC tool to assess infrastructure vulnerability to projected extreme weather and climate change. Using multi-disciplinary/stakeholder and local knowledge/experience inputs

Commotion Creek Hwy 97 2016

Peace Region Flooding 2016

BC Assessment Sites

- 2010 Coquihalla Highway
- 2011 Yellowhead Highway
- 2013 Bella Coola, Stewart, Pine Pass
- Sites have different geographic and climatic conditions

Yellowhead

Coquihalla

Highways are generally resilient to climate change except for extreme precipitation events; further research is required for events such as rain on snow, fog and wind, avalanche, landslides, sea level rise, etc.

Yellowhead Hwy

Bitter Creek Bridge, Stewart, Sept 2011

Lessons Learned to Date

- Develop awareness of climate change/extreme weather and implications (primarily water related events)
- Include climate adaptation in organizational practice
- Use multidisciplinary teams for projects
- Use qualified professionals with local knowledge (climate, meteorological, hydrotechnical)
- Adaptation education for professionals, consultants, staff and students

Batnuni Bridge 2018

Narcosli Bridge 2018

Best Practices

- Monitor **data** used in current codes and standards and develop climate resilience specific codes
- Use data and/or professional judgement
- Apply sensitivity analysis
- Understand risks and uncertainties
- Review association guidance

Bella Coola, Sept 2010

- Use information from ensemble of climate models
- Determine best models and data to use

In 2014-15, ACECBC consultants, EGBC, PCIC and BCMOTI partnered in developing a technical circular considering climate adapted design for highway reliability

Grand Forks, May 2018

Technical Circular Requirements

- Design for climate change and extreme weather event from model projections
- Vulnerability screening analysis for the design life of structures and components including data sources
- Development of practical and affordable design criteria
- Design Criteria Sheet to summarize climate parameter changes

Design Sheet Example

BC MoTI Design Criteria Sheet for Climate Change Resilience

Highway Infrastructure Design Engineering and Climate Change Resilience

Ministry of Transportation and Infrastructure

Project:	Project No. 12573 Highway 1 at Mountain Highway Interchange
Type of Work:	Interchange Improvement
Location:	Highway 1 at Mountain Highway Interchange, North Vancouver, BC LKI Segment 0515 km 6.18
Discipline	Drainage

Design Component	Design Life or Return Period		Design Criteria + (Units)	Design Value Without Climate Change	Change in Design Value From Future Climate	Design Value Including Climate Change	Comments / Notes / Deviations / Variance
	D.L.	R.P.					
<u>Major Drainage System</u>							
Culverts < 3000 mm	50 yr	100 yr	Flow Rate [m3/s]	18.1	+20%	21.7	
Keith Creek	-	100 yr	Flow Rate [m3/s]	18.1	+20%	21.7	
<u>Minor Drainage System</u>							
Storm Sewer – MoTI	-	25 yr	Intensity [mm/hr]	Varies	+20%	Varies	
Storm Sewer – CNV / DNV	-	10 yr	Intensity [mm/hr]	Varies	+20%	Varies	
Catchbasin - All	-	10 yr	Intensity [mm/hr]	Varies	+20%	Varies	

Explanatory Notes / Discussion:

1. Plan2Adapt Tool (PCIC Website)
   a. Annual Precipitation estimated to increase by ~7% (Mean) ~10.5% (75th Percentile) ~ 17.5% (90th Percentile), for year 2065.
2. APEGBC Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC
   a. If no historical trend is detectable, apply a 10% increase (to year 2100)
   b. If there is a significantly detectable trend, apply a 20% increase (to year 2100)
3. IDF-CC Tool (Western University / Canadian Water Network)
   a. Ensemble mean estimates approximately a 18% / 18% / 23% increase in rainfall to the year 2065 (assumes RCP 8.5 climate change scenario), for Environment Canada rain gauges North Vancouver Lynn Creek / Vancouver Harbour CS / North Vancouver Sonora Drive.

Recommended by: Engineer of Record:
(Print Name / Provide Seal & Signature) ______________________

Date: 2016-01-29 ______________________

Engineering Firm: ______________________

Accepted by BC MoTI Consultant Liaison: ______________________

Deviations and Variances Approved by the Chief Engineer: ______________________

Program Contact: Dirk Nyland, Chief Engineer BCMoTI

Rev.0

EGBC Practice Guidelines

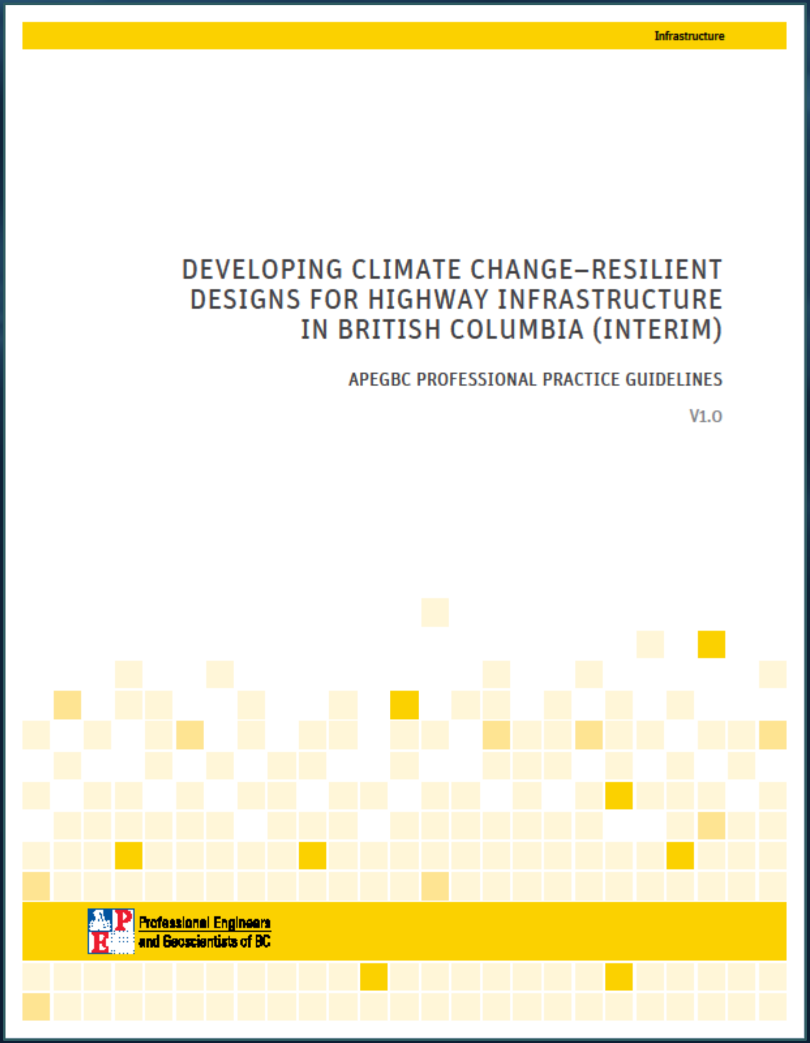
Request for Proposal (2.2.1.1)

Define Highway Infrastructure project (3.2)

Conduct screening-level, climate change risk assessment (3.3)

Identify and incorporate climate adaptation options (3.4)

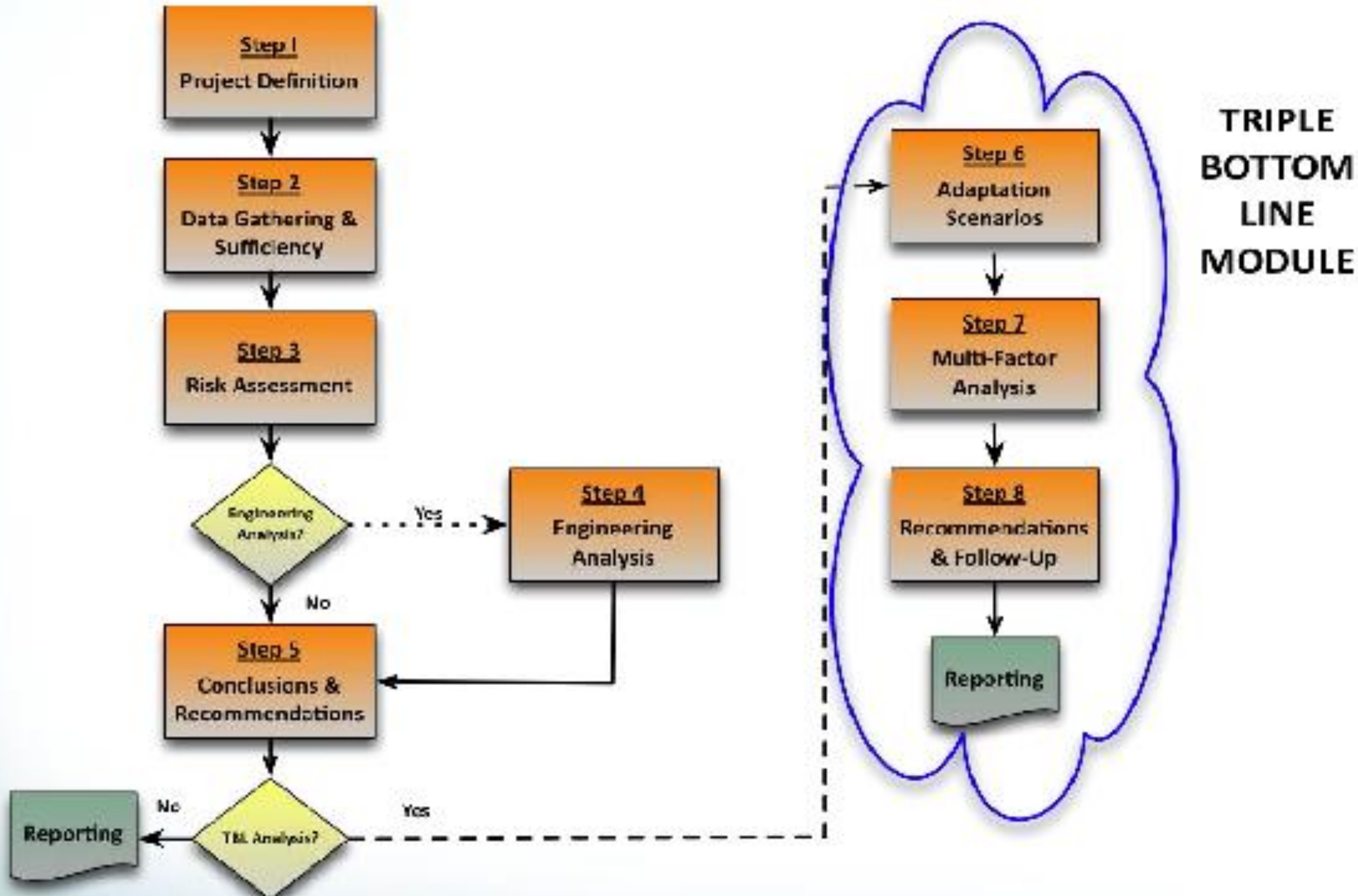
Documents (3.5)
- Climate change risk assessment
- Hwy resilient design report
- Assurance statement
- BCMoTI Design Criteria Sheet



George Massey & Pattullo Bridges Project Agreements – Climate change Section

- The Concessionaire shall comply with Technical Circular T-06/15
- Consider at a minimum, temperature, rain, snow, ice, fog, hail, frost, humidity, ice accretion, wind, floods, extreme temperatures and precipitation, and storms of various intensities
- Rely on current climatological modelling analysis relevant to Greater Vancouver area of BC
- Assess how vulnerability risks are anticipated to change over the Design Life
- Assess potential impacts and identify proposed actions

Vulnerability Screening - PIEVC



Types of Data for Vulnerability Assessment

- Infrastructure Components
- Infrastructure Age
- Availability of Infrastructure Data
- Geotechnical Indicators
- Variety of Terrain
- Traffic Volumes
- Strategic Importance of Route
- Occurrence of Extreme Environmental Events
- Historic Weather Data Available
- Current Weather Data Available
- Expected Climatic Change – Temperature
- Expected Climatic Change – Precipitation
- Climatic Regions
- Sea Level Rise

Infrastructure Components

- Surface asphalt
- Bridges
- Ditches
- Catch basins
- Culverts
- Third-party utilities

Kootenay Pass 2018

Salmon Arm 2018

Climate Projections – Design for Extremes

- Extreme rainfall in one or more days (e.g. >76 mm/24 hrs)
- Atmospheric River- Pineapple Express (e.g. >150 mm/24 hrs)
- High Temperature (e.g. number of days over 30°C)
- Temperature variability (e.g. freeze-thaw)
- Sea level rise

Cariboo 2018

Hwy 97 June 2016

Design implications for **higher temperature and precipitation** over lifecycle of components, i.e. pavement (15-20 years), culverts (75 years), bridges (50-100 years)

Nazko 2018

Revelstoke Hwy 23N 2018

Bridges and Structures	
Hydrotechnical Design – Scour	
Current Standards	Maximum instantaneous discharge (Q200) Clearance between design water surface and bridge soffit (ie. 1.5 m)
Climatic Inputs	• Historic streamflow from hydrometric gauges • Historic precipitation from weather stations
Climate Change Risk Issues	• Changes in streamflow (Q200) • Changes at watershed scale (land use & vegetation) • Changes in channel scale (stability, sediment transport)
Potential Adaptation Measurer	• Estimate and use future streamflow (Q200) • Structure clearance, size, clear span • Construction quality (riprap) • Debris control • Maintenance for debris and sediment

Bridges and Structures	
Thermal Movement	
Current Standards	Canadian Highway Bridge Design Code
Climatic Inputs	Temperature allowance in excess of max and min mean daily temperature
Risk Issues	• Increase in temperature • Temperature extremes • (Note: for general bridge design – risk may be low. Temperature changes may be small relative to accuracy of bridge code values)
Adaptation Values	NRC incorporate projected future temperature maps in code

Geotechnical	
Slope Stability	
Current Standards	Safety factor 1.5
Climatic Inputs	Current conditions and moisture changes
Risk Issues	• Increased precipitation • Groundwater changes • Changes in land use and vegetation • Higher flow volumes and velocities
Adaptation Values	Compare recent conditions and future climate projections

Geotechnical	
Pavement Grade - Asphalt Cement Mix	
Current Standards	Standard Specification 952
Climatic Inputs	Pavement Grade values based on historic temperature and use
Risk Issues	Increased temperatures
Adaptation Values	Modify PG rating based on future temperature and use

Change in Projected Flows
(Model Averages)

Model Output	Location	Average Change Relative to Historic 2040-2069
200-year Hourly Peak Flow (m^3/s) (% change to historic)	Bitter Creek (Stewart)	34
	Medby Creek (Bella Coola)	35
	Fisher Creek (Pine Pass)	39

Adapted Bridge Designs - Flow

Region	Return periods from sheets vary	% ↑ Design Value for Climate Change	Climate Data
NR	100-200yr	+9% to +30%	-MoTI practices -EGBC recommendations* -PCIC regional reports -IDFCC -Consultant Reports
SIR	100-200yr	+10% to +20%	-MoTI practices -EGBC recommendations* -PCIC -Consultant Reports
SCR	200yr	+11% to +15%	-MoE coastal guidelines -EGBC recommendations* -Consultant Reports

Adapted Culvert Designs - Flow

Region	Return periods from sheets vary	% ↑ Design Value for Climate Change	Climate Data
NR	50-200yr	+10% to +25%	- IDFCC - Consultant reports
SIR	25-200yr	+10%	- MoTI - EGBC recommendations* - Consultant Reports
SCR	5-200yr	+3.6% to +25%	- EGBC recommendations* - PCIC - IDFCC - Consultant Reports

Zonnebeke Creek – Culvert Replacement

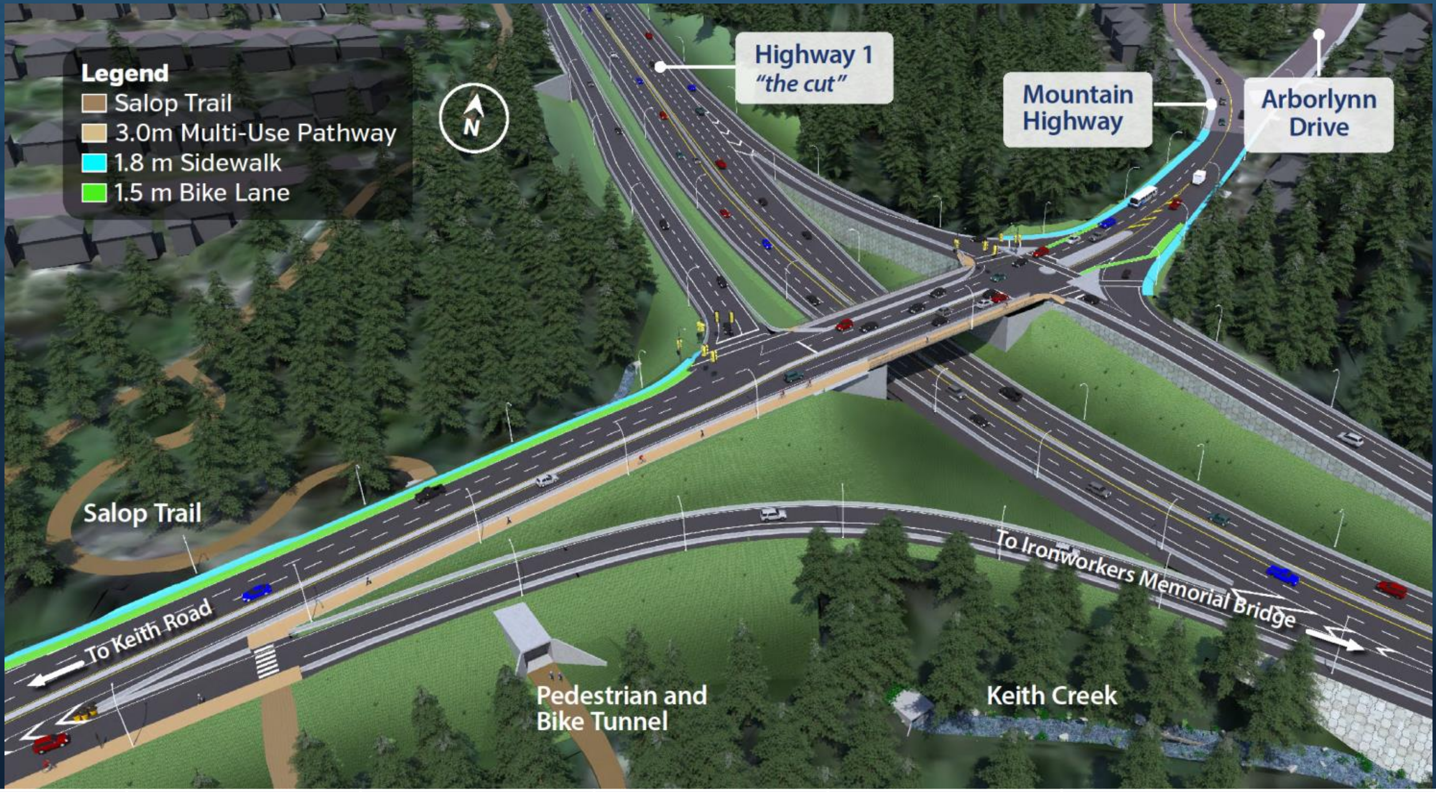
(Design $1 million / Construction $10 million)

Zonnebeke Creek Culvert Replacement Hwy 29S	Culvert (6,470 mm SPCSP)	Return 200yr	Flow Rate (m^3/s) 61.6	Climate Change +25%	New Flow Rate (M^3/S) 77	NHC IDFCC Report on the 2016 Flood Event and Regional Hydrology – NHC, 2017

McKenzie Interchange
(Critical Sewer Segment 2 of 10)

Admirals-McKenzie Interchange Hwy 1	Critical Sewer Segment #2	200yr	Flow Rate (l/s) 711	Climate Change +18.4%	Flow Rate (l/s) 842	Urban Systems Future IDF curves

Mtn Hwy Interchange



Mountain Hwy Interchange Hwy 1	Major Drainage systems Keith Creek Culverts	100yr (75yr DL)	Flow Rate (m^3/s) 18.1	Climate Change +20%	Flow Rate (M^3/S) 21.7	Associated Engineering PCIC (Plan2Adapt 90^{th}% 17.5%↑) APEGBC (10%, 20%↑) IDFCC (18-23%↑)

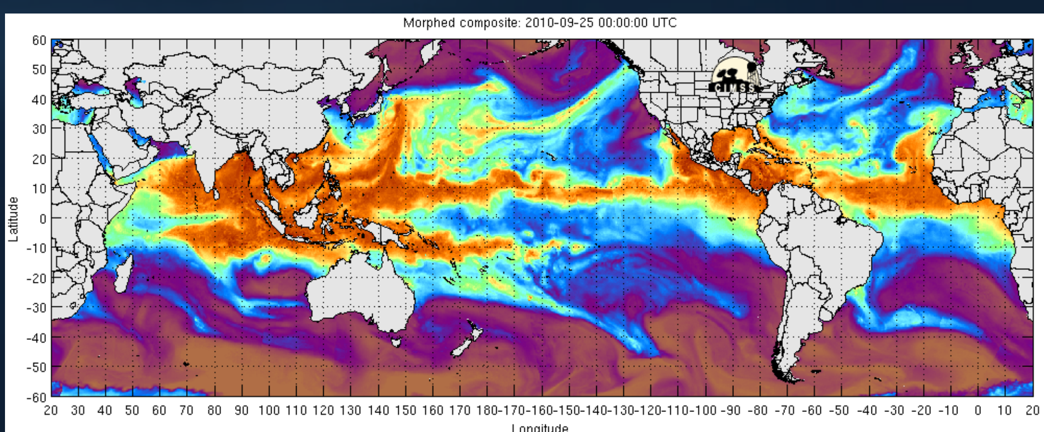
BCMoTI Continuing Work

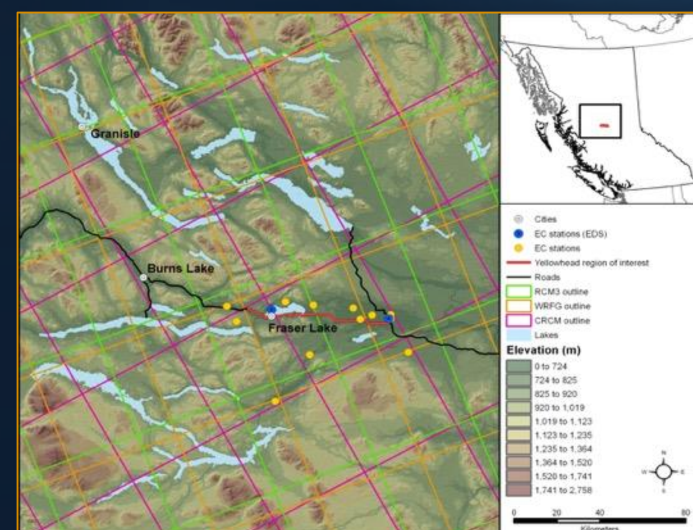
- NRCan Project – interdependencies and adaptation economic analysis
- PCIC Climate Explorer

Climate Resources

PCIC Climate data portal and support

- Plan2Adapt
- Downscaled climate data - projections
- Hydrologic model output – projections
- Engineering specific tool – projections (in development)
- Support from climate scientists





PACIFIC CLIMATE IMPACTS CONSORTIUM

PLAN2ADAPT

PCIC Home | Contact Us

Summary

Region & Time

Temperature

Precipitation

Snowfall

Growing DD

Heating DD

Frost-Free Days

Impacts

Notes

References

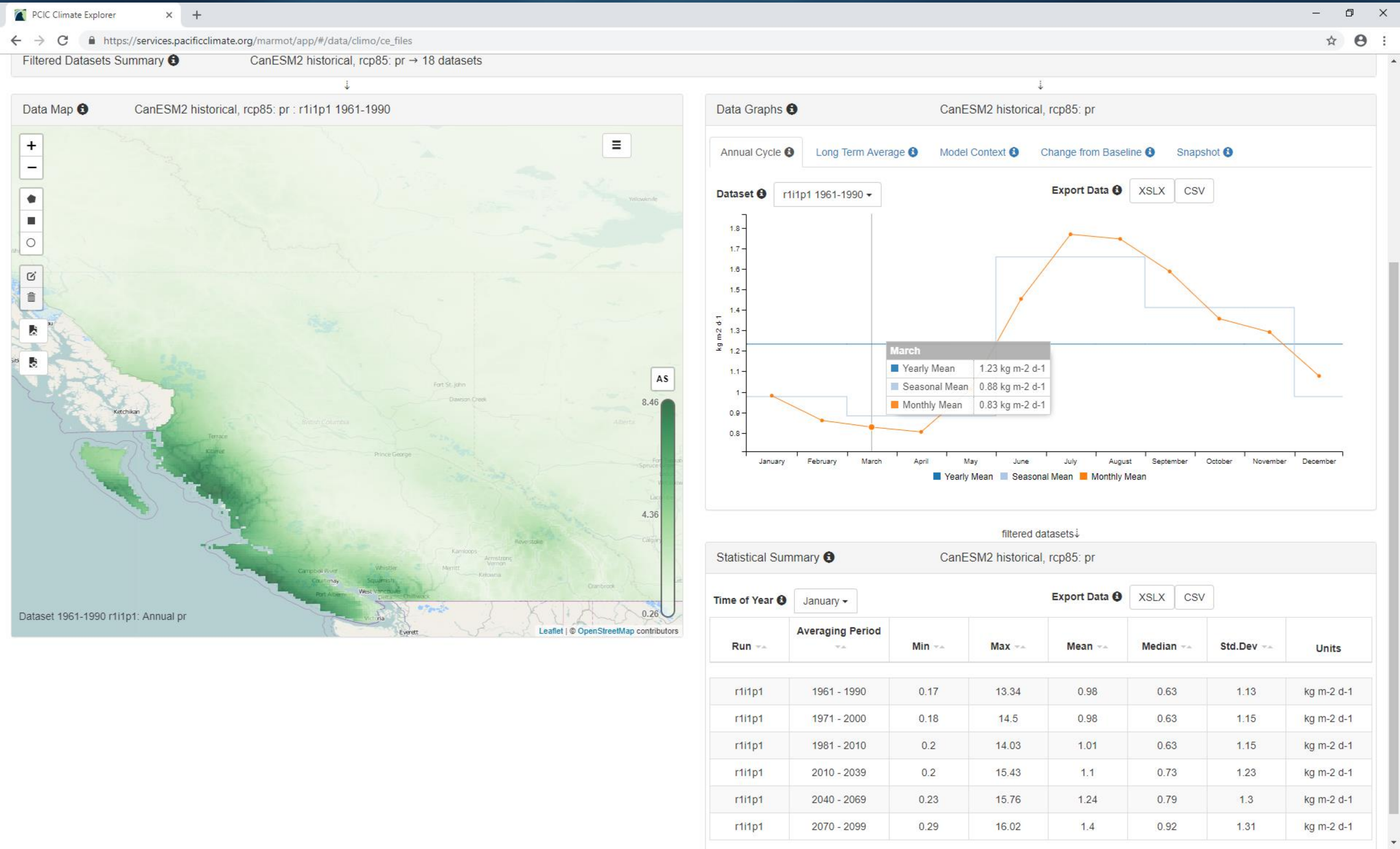
Summary of Climate Change for British Columbia in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.8 °C	+1.3 °C to +2.7 °C
Precipitation (%)	Annual	+6%	+2% to +13%
	Summer	-1%	-8% to +7%
	Winter	+8%	-2% to +15%
Snowfall* (%)	Winter	-10%	-17% to +2%
	Spring	-58%	-71% to -11%
Growing Degree Days* (degree days)	Annual	+283 degree days	+177 to +429 degree days
Heating Degree Days* (degree days)	Annual	-648 degree days	-955 to -454 degree days
Frost-Free Days* (days)	Annual	+20 days	+12 to +29 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2050s** for the **British Columbia** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

PCIC Climate Explorer



BCMoTI Adaptation Site

BCMoTI Adaptation site:
https://www2.gov.bc.ca/gov/content/transportation/transportation-environment/climate-action/adaptation

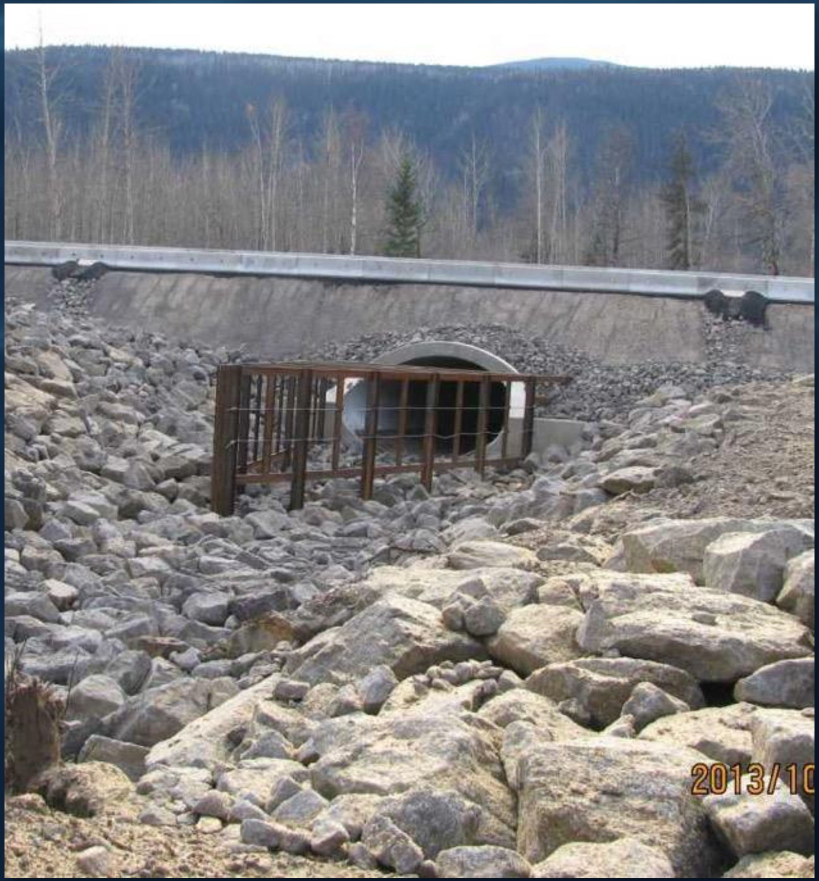
Sportsman Bowl Rd 2018

Old Kamloops Rd Hwy 5A 2018

Recap

Adapt highway infrastructure for resilience to extreme events and climate change using vulnerability assessment and climate projection tools

Thank you. Questions?



Grizzly Creek Culvert
Trash Rack – Flying V (2013)