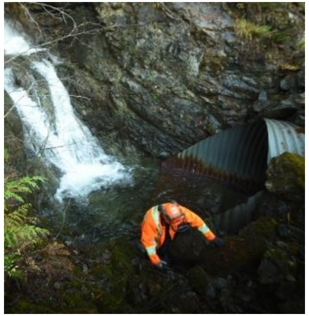
Accounting for Climate Change Impacts in the Design of Resource Road Crossings



(Webinar #7) Designing Resource Road Stream Crossings Considering Climate Change: Two Case Studies from Coastal B.C.

January 14th, 2021

Lee Deslauriers Principal and Managing Engineer, StoneCroft Engineering

Matt Kurowski Research Engineer, FPInnovations

Join at

slido.com

#fpi

- The session will start at 10:00 PST / 13:00 EST
- All lines will be muted during the presentation
- This webinar will be recorded and posted to FLRNORD website
- **Interact! Vote on polls and ask/upvote questions**

slido.com event code: **fpi**

StoneCroft Engineering

FPInnovations®

British Columbia

Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Small watershed crossings and climate change

- Brian Chow, P.Eng. (Chief Engineer, FLNRORD)

BRITISH COLUMBIA | Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Panel

- Jeremy Fyke, Ph.D. (Canadian Centre for Climate Services)
- Paul Mysak, P.Eng. (Onsite Engineering Ltd.)
- Arelia Schoeneberg, M.Sc. (Pacific Climate Impacts Consortium)
- Kari Tyler, M.Ed. (Pacific Climate Impacts Consortium)

Influence and Contribute to the Presentation!

Step 1 - go to slido.com (on phone or computer)

fpi

Step 2 - Joining as a participant? # Enter code here

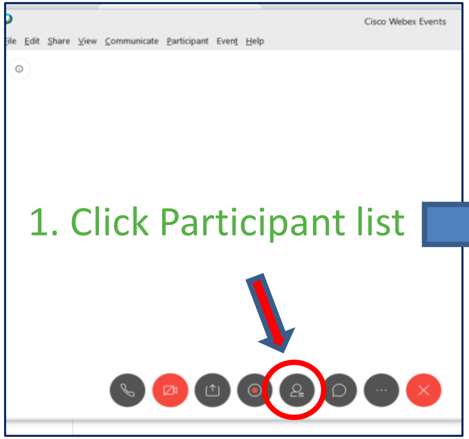
Anonymous by default

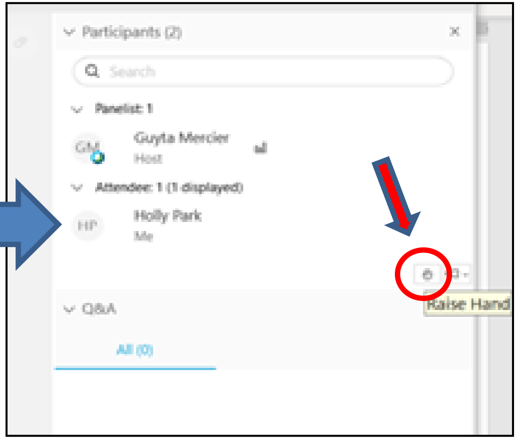
- Vote on live polls
- Ask and upvote questions/comments

Speaking & Login ID Questions/Comments

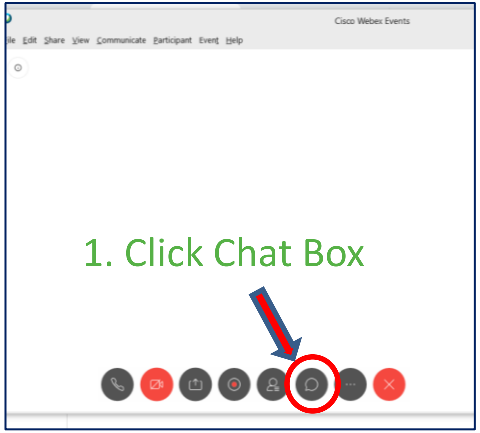
1. Use WebEx to voice a comment/question

2. A Menu pops up – click “raise hand”





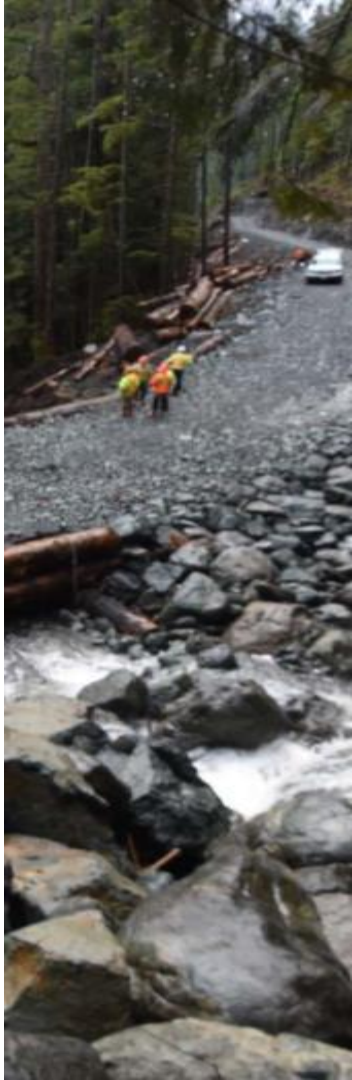
2. Use WebEx Chat to
- ask tech support questions
- comment/question using WebEx login ID (publicly or privately)



- **Poll 1!**
  - **Go to slido.com**
  - **Event code is “fpi”**

Webinar Outline

- (15 min) **Intro + 3 methods that account for climate change impacts in small watershed design floods**
  - Situating 5 publicly available tools (Matt)
- (50 min) **Two case studies (34 km^2 & 0.3 km^2 basins)**
  - Design review - (Lee)
  - Outputs from 5 climate tools (Matt)
  - Rationalizing climate impacts for the design (Lee)
- (25 min) **Discussion**:
  - Comments/questions (panelists, attendees)



How are climate projections derived?

- ~40 global climate models (GCMs)
  - ~10 000 km^2 daily/monthly grids
  - Use physics simulations and historic data as basis for projecting future
  - Each GCM runs many permutations (staring conditions)
  - Significant computations required
- GCMs have baked-in representative concentration pathway (RCPs) for future conditions
  - Best -> worst scenarios for future carbon emissions: **2.6, 4.5, 6.5, 8.5**
- Statistical methods can combine GCMs with regional / local data to “downscale” GCMs to higher spatiotemporal resolutions:
  - **Canada: daily resolution ~56 km^2 grid for temperature & precipitation 1950-2100**

PACIFIC CLIMATE IMPACTS CONSORTIUM

How are climate projections summarized?

- **Climate indices**: statistical summaries of climate – e.g.
  - maximum consecutive days with no rain
  - daily maximum precipitation in the fall season
  - average number of days/year that reach 20 degrees
  - 5-day daily antecedent rain >15mm
- **Standardized future periods**:
  - Three common periods: near, mid, and far future
  - **2020s** (2010-2039), **2050s** (2040-2069), **2080s** (2070-2099)

How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

All precipitation-based

ClimateBC_v6.20

PLAN2ADAPT

IDF_CC Tool 4.0

COLUMBIA BASIN CLIMATE SOURCE

PCIC Climate Explorer

ClimateData.ca

How are climate projections made accessible?

projection

Why not publicly available **climate tools ?**

climate change tools?

- Interactive maps that show – or use – climate index grids with historical and future periods

ClimateBC_v6.20

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IDF_CC Tool 4.0

COLUMBIA BASIN CLIMATE SOURCE

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How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Can be used to calculate historic IDF curves

ClimateBC_v6.20

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IDF_CC Tool 4.0

COLUMBIA BASIN CLIMATE SOURCE

PCIC Climate Explorer

ClimateData.ca

How are climate projections made accessible?

useful for climate change impacts to snowmelt-dominated peak flows??

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Not for historic data (only for projections that reference simulated historic data)

ClimateBC_v6.20

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IDF_CC Tool 4.0

COLUMBIA BASIN CLIMATE SOURCE

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How are climate projections made accessible?

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  - Interactive maps that show – or use – climate index grids with historical and future periods

British Columbia

ClimateBC_v6.20

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PCIC Climate Explorer

Entire Canada

IDF_CC Tool 4.0

ClimateData.ca

SE British Columbia

COLUMBIA BASIN CLIMATE SOURCE

How are climate projections made accessible?

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British Columbia

ClimateBC_v6.20

PLAN2ADAPT

PCIC Climate Explorer

Entire Canada

IDF_CC Tool 4.0

ClimateData.ca

How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Desktop software

ClimateBC_v6.20

Access via internet browser

PLAN2ADAPT

IDF_CC Tool 4.0

PCIC Climate Explorer

ClimateData.ca

How are climate projections made accessible?

- Publicly available **climate tools**
  - Interactive maps that show – or use – climate index grids with historical and future periods

Also access via internet browser – but less features

Centre for Forest Conservation Genetics • CFCG •

ClimateBC_Map

-- A Interactive Platform for Visualization and Data Access

Access via internet browser

PLAN2ADAPT

IDF_CC Tool 4.0

PCIC Climate Explorer

ClimateData.ca

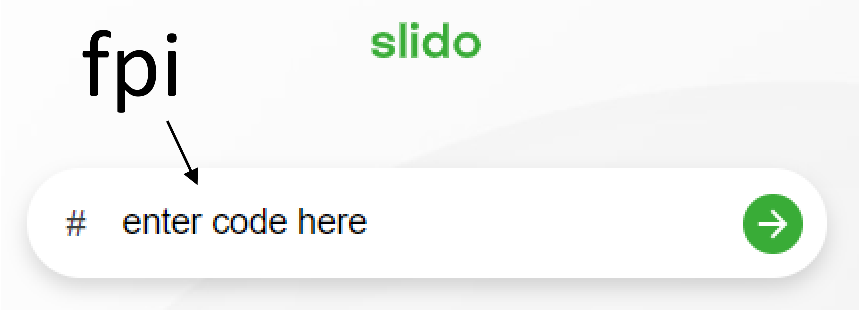
There is no agreed upon method

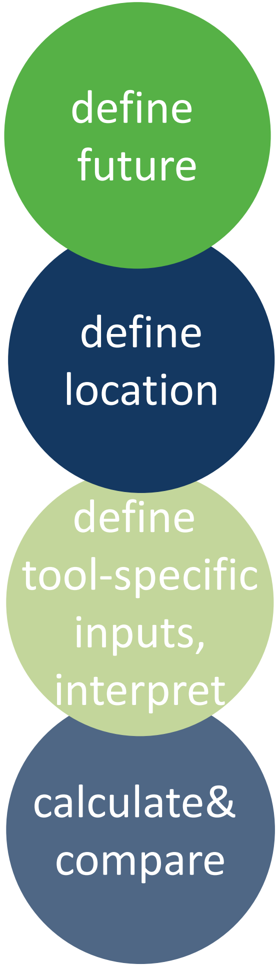
- **Especially for small watersheds**
- This webinar **will not provide** THE answer for how to take climate change into account in design flood calculations
- This webinar **will provide** a way forward by exploring different options and discussing options

3 approaches that account for climate change

1. **Use IDF_CC while being aware of its methods, limitations, and assumptions**
   - Uses climate indices within background calculations and outputs IDF curves at point locations with high temporal resolution (down to 5 minutes)
   - Professional guidance: be aware of projections of sub-daily values as this assumes stationarity of the relationships between daily and sub-daily events – especially when 30+ years in future (Engineers and Geoscientists BC, 2018)
2. **Use climate index-based climate tools alongside your professional judgement**
   - Professional judgement must i) select a climate index related to local extreme flooding, and ii) assume how the daily (or greater) resolution of the climate index relates to finer temporal resolution required for a local scale
   - Professional guidance does not outline this approach explicitly, but has advice that can justify it (Engineers and Geoscientists BC 2018; 2020)
3. **Use no climate tools**
   - When a small watershed has little or no local historic data, a designer can account for climate change by increasing flow by an additional 20% (Engineers and Geoscientists BC, 2018)

- **Poll 1 – lets look at results**
- **and then start Poll 2**





Steps to using a climate tool

1. Define the required input parameters, or be aware of assumptions
   - GCMs related to downscaled models
   - RCPs baked-in to GCMs
   - Baseline and future periods that define measure of change
2. Define the location of interest
3. For IDF_CC:
   - Select duration/frequency/return period to define intensity. Interpret.

   For climate index climate tool:
   - Select relevant climate index that impacts design flood and assume how its temporal resolution (daily+) relates to local scale (minutes to hours). Interpret.
4. Calculate the change in flow, compare results between climate tool outputs

Applying climate tools adds uncertainties

- Choices in:
  - Global climate models (GCM) ensembles
    - Use average, or upper percentiles of distribution?
  - Representative concentration pathway (RCP) scenarios
    - Assume that climate treaties can be effective?
  - Historic baseline reference period
  - "Proxy" climate index
    - Assume known metric that relates to local scale flooding (if not using IDF_CC)
  - Assumptions that extrapolate from available data
    - changes to climate indices at a daily (or greater) resolution relate to sub-daily resolution (downscaling using professional judgement) – when using climate index tools
    - stationarity of relationships between daily (or greater) and sub-daily events – when using any climate tool
- **Review of the design flood hydrology at a site gives context**
  - What are the other uncertainties aside from climate tool inputs?

- **Poll 2 results**

Getting a percent change for design flood

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ClimateBC_v6.20

PCIC Climate Explorer

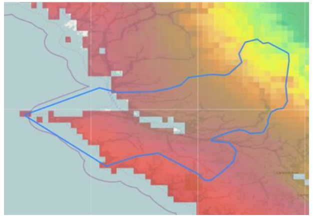
ClimateData.ca

IDF_CC Tool 4.0

Climate tools: case study 1

PLAN2ADAPT

Proxy: total precipitation (winter)



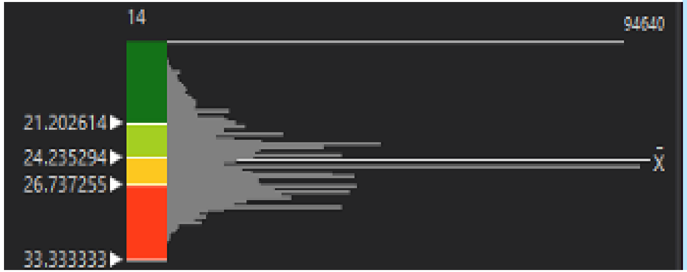
	RCP	10th percentile	Average	90th percentile
2010-2039	RCP 8.5	-5%	1%	9%
	RCP 4.5	N/A	N/A	N/A
2040-2069	RCP 8.5	-5%	2%	6%
	RCP 4.5	N/A	N/A	N/A
2070-2099	RCP 8.5	-0%	7%	16%
	RCP 4.5	N/A	N/A	N/A

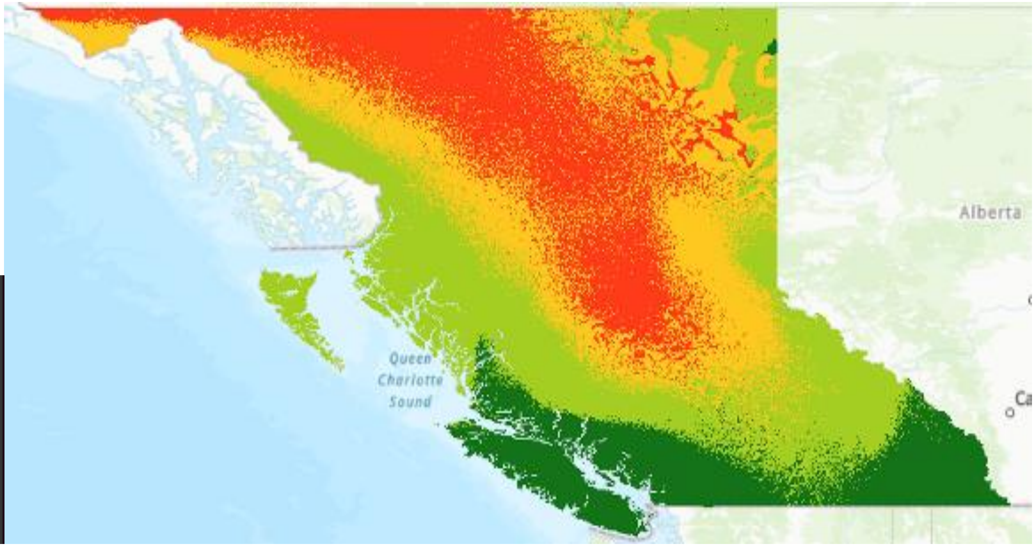
(ensemble: 12 GCMs)

Climate tools: case study 1

Many climate indices, max temporal resolution = monthly

Unique benefit of this climate tool: desktop version can output entire maps





Climate index: total precipitation in November

% change: 2070-2099 period (15 GCMs)

Producing this type of % change map requires GIS post-processing

Applying climate tools: case study 1

PCIC Climate Explorer

2040-2069

RCP 8.5

Proxy climate index: many to choose from…

Climate index
Total precipitation (winter)
Total precipitation (January)
Daily precipitation (yearly storm)
Daily precipitation (20-year storm)
Daily precipitation (50-year storm)

Applying climate tools: case study 1

PCIC Climate Explorer

2040-2069

RCP 8.5

Ensemble option:

12 GCMs

Climate index	Low perc.	Average	High perc.
Total precipitation (winter)	N/A	5 to 7%	N/A
Total precipitation (January)	N/A	3 to 7%	N/A
Daily precipitation (yearly storm)	N/A	N/A	N/A
Daily precipitation (20-year storm)	N/A	13 to 19%	N/A
Daily precipitation (50-year storm)	N/A	17 to 25%	N/A

Variance shown: 3 different historic baselines (of 30 years)

Applying climate tools: case study 1

PCIC Climate Explorer

2040-2069

RCP 8.5

Manually averaging global climate models (GCMs) →

Climate index	Low perc.	Average	High perc.
Total precipitation (winter)	N/A	5 to 7%	N/A
Total precipitation (January)	N/A	3 to 7%	N/A
Daily precipitation (yearly storm)	16 to 19% (min of 4)	21 to 31%	40 to 54% (max of 4)
Daily precipitation (20-year storm)	N/A	13 to 19%	N/A
Daily precipitation (50-year storm)	N/A	17 to 25%	N/A

Order	WNA
1	CNRM-CM5-r1
2	CanESM2-r1
3	ACCESS1-0-r1
4	inmcm4-r1
5	CSIRO-Mk3-6-0-r1
6	CCSM4-r2
7	MIROC5-r3
8	MPI-ESM-LR-r3
9	HadGEM2-CC-r1
10	MRI-CGCM3-r1
11	GFDL-ESM2G-r1
12	HadGEM2-ES-r1

Which GCMs to pick if not all 12 for BC?

https://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios

Variance shown: 3 different historic baselines (of 30 years)

Applying climate tools: case study 1

PCIC Climate Explorer

2040-2069

RCP 8.5

Daily precipitation (yearly storm) – another source

Climate index	10th perc.	Average	90th perc.
Total precipitation (winter)	N/A	5 to 7%	N/A
Total precipitation (January)	N/A	3 to 7%	N/A
Daily precipitation (yearly storm)	-12%	14%	72%
Daily precipitation (20-year storm)	N/A	13 to 19%	N/A
Daily precipitation (50-year storm)	N/A	17 to 25%	N/A

Available (23 GCMs) →

ClimateData.ca

Applying climate tools: case study 1

IDF_CC Tool 4.0

2040-2069

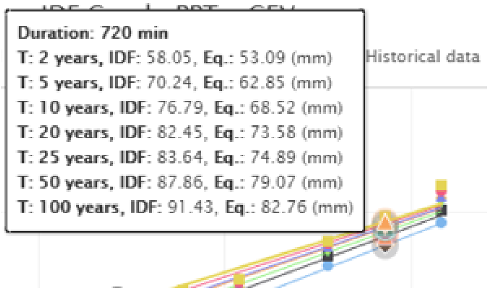
RCP 8.5

2040-2069

RCP 4.5

Duration	25th perc.	Average	75th perc.
60 mins	**9%**	**13%**	**30%**
720 mins	**12%**	**18%**	**33%**
60 mins	-4%	9%	14%
720 mins	-2%	12%	19%

IDF point as baseline



Applying climate tools: case study 2

IDF_CC Tool 4.0

2010-2039

RCP 8.5

2040-2069

RCP 8.5

Duration	25th perc.	Average	75th perc.
30 mins	**0%**	**5%**	**25%**
60 mins	**-2%**	**6%**	**25%**
30 mins	0%	10%	25%
60 mins	4%	13%	25%

PCIC Climate Explorer

Climate index	Average
Daily precipitation (50-year storm)	4 to 8%
Daily precipitation (50-year storm)	19 to 22%

FPInnovations

Thank you

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