Incorporating Climate Resilience in the Design of Highway Infrastructure in BC

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GWF Extremes Meeting - Winnepeg

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BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

CLIMATE CHANGE

- Future climate change and extreme event considerations
- Significant impacts even with CO_2 emission mitigation
- Adaptation involves preparing for economic, social and environmental impacts of climate change

PRECIPITATION & INFRASTRUCTURE

2050s Precipitation

- Winter: up to 20% wetter throughout BC
- Summer:
  - North from 10% drier to 10% wetter
  - South up to 15% drier
- Increase in precipitation intensity

Commotion Creek Hwy 97 2016

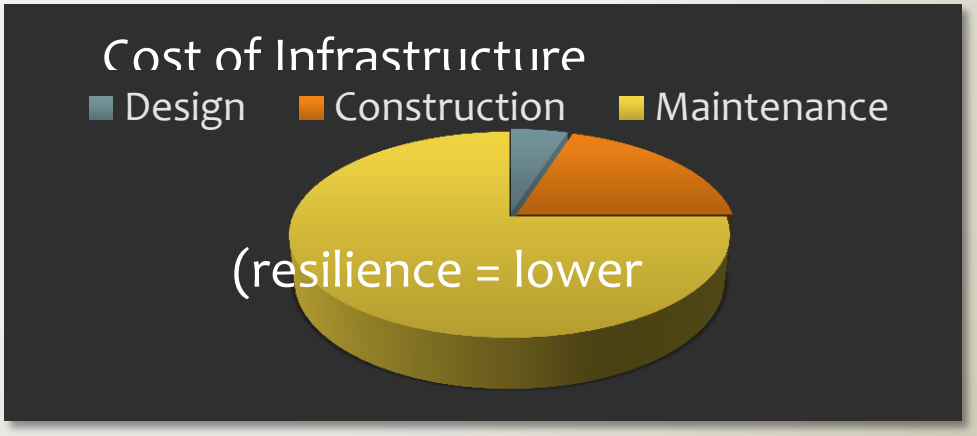
Peace Region Flooding (2016)

Dawson Creek (2016)

MOTIVATION TO ADAPT

- Considering character, magnitude and rate of change of climate and extreme weather events
- Impact potential on design, operation and maintenance
- Adapt engineering design practices for resilient, reliable, efficient and effective transportation infrastructure

Bitter Creek Bridge
(Stewart, BC – Sept 2011)



TRAN CLIMATE VULNERABILITY ASSESSMENT

- Civil Engineering tool to assess climate vulnerability and extreme weather events on infrastructure
- TRAN involved in Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol

Yellowhead

Coquihalla

PIEVC TOOL

- Identify infrastructure vulnerability-risk to extreme weather and climate change to develop resiliency in design
- Multi-disciplinary, multi-stakeholder
- Local knowledge and experience

DATA INPUTS 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

DESIGN IMPLICATIONS

Design depends on structural components design life and site:

- Pavement 15-20 years, culverts 75 years, bridges 50-100 years
- Design for potentially higher temperatures and precipitation in many parts of the province
- Review temperature and precipitation sensitive components
- Climate and product specification changes (e.g. pavement grades)

Fur Thief Creek Culvert (Pine Pass)

Fisher Creek Bridge
(Pine Pass, June-July 2011)

LESSONS LEARNED

Bitter Creek Bridge (Stewart, Sept 2011)

- 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 & students

TRAN TECHNICAL CIRCULAR T06-15

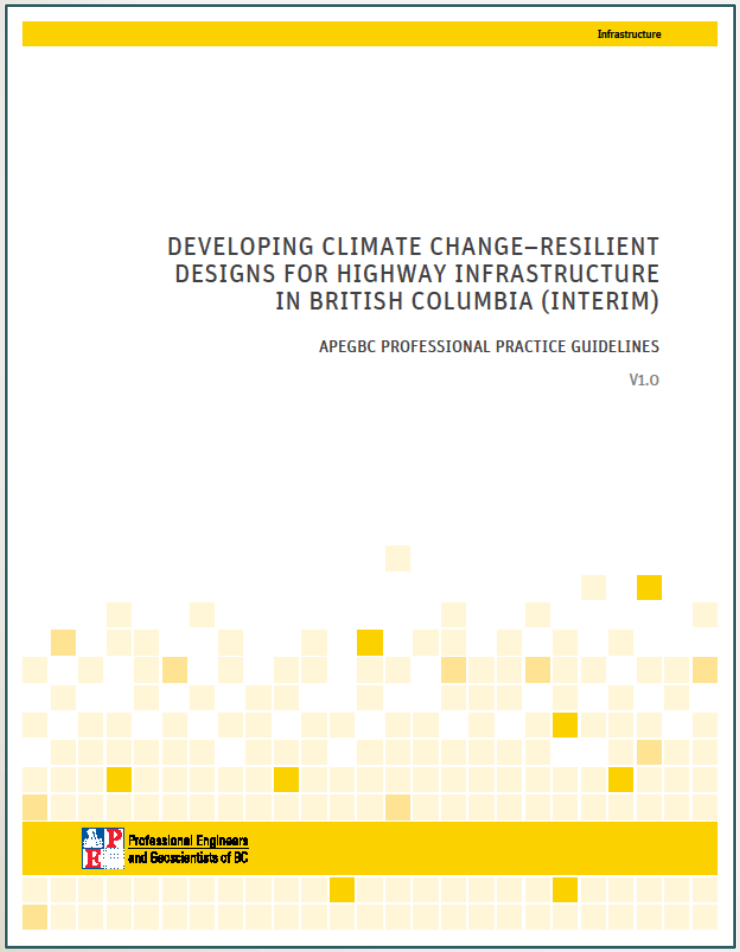
- Given apparent non-stationarity of climate . . .
- TRAN developed Technical Circular – require staff/consultants to consider climate change and extreme weather adapted design for highway reliability
- Input from ACECBC – consulting engineer committee

(T06-15 Climate Change and Extreme Weather Event preparedness and Resilience in Engineering Infrastructure Design)

REQUIRED FOR ENGINEERING DESIGN PROJECTS

- Design which takes into account climate change and extreme weather event projections and analyses
- Vulnerability analysis for the design life of components
- Climate and vulnerability screening information and sources
- Development of practical and affordable project design criteria which takes adaptation to climate change into account
- TRAN Design Criteria Sheet to summarize climate change parameter changes

EGBC (APEGBC) PRACTICE GUIDELINES



Request for Proposal

Define Highway Infrastructure project

Conduct screening-level, climate change risk assessment

Identify and incorporate climate adaptation options

Documents
- Climate change risk assessment
- Hwy resilient design report
- Assurance statement
- TRAN Design Criteria Sheet

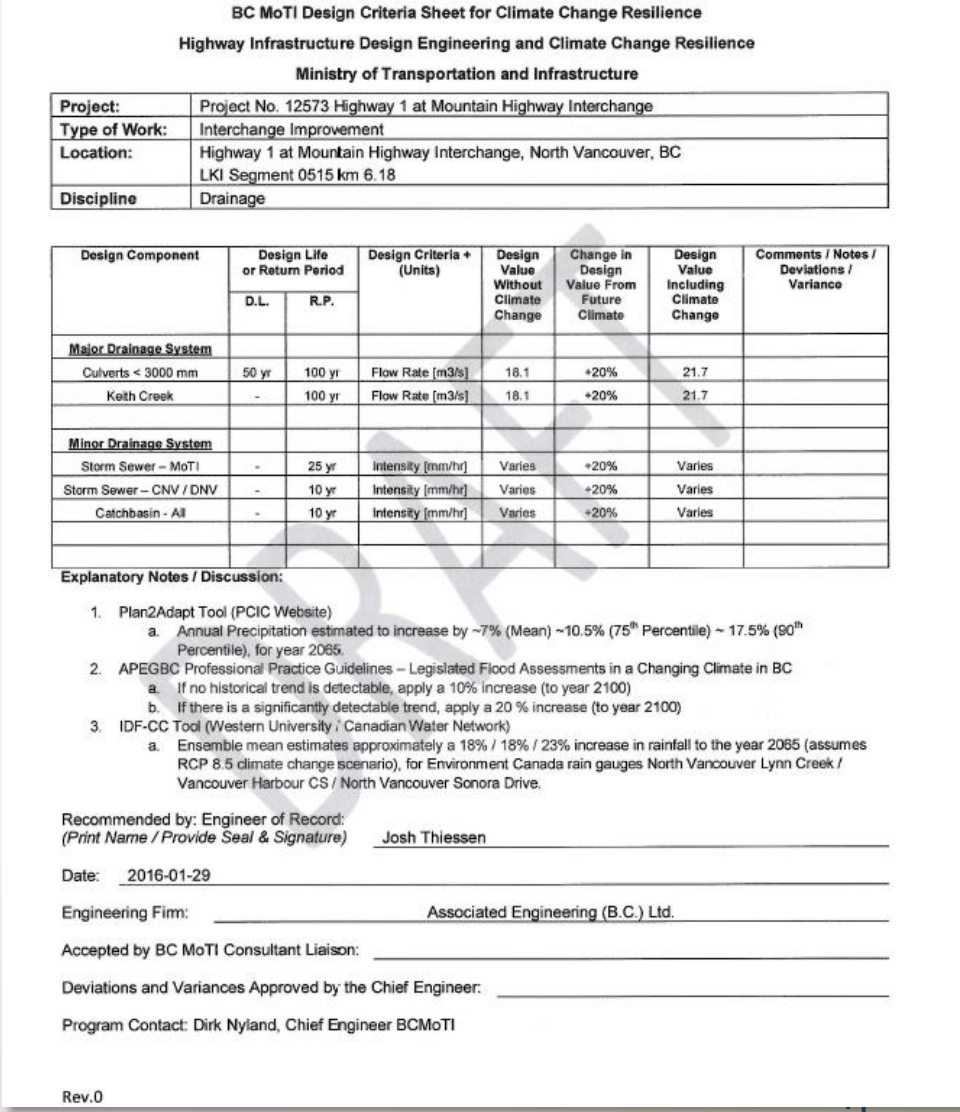
TRAN HIGHWAY INFRASTRUCTURE PROJECTS

STANDARD OF PRACTICE

- Establish owner defined time-horizon for the infrastructure
- Assemble qualified team in collaboration with the owner
- Use climate projections and relevant historical information in engineering judgement
- Use risk management to address uncertainties
- Explore the climate adaptation methods with the owner
- Communicate and document decisions

T-CIRCULAR DESIGN CRITERIA SHEET REVIEW

- List Design Criteria
- Conclusions
- Documentation



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.					
Major Drainage System							
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	
Minor Drainage System							
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 2085.
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 2085 (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) Josh Thiessen

Date: 2016-01-29

Engineering Firm: Associated Engineering (B.C.) Ltd.

Accepted by BC MoTI Consultant Liaison: _____

Deviations and Variances Approved by the Chief Engineer: _____

Program Contact: Dirk Nyland, Chief Engineer BCMoTI

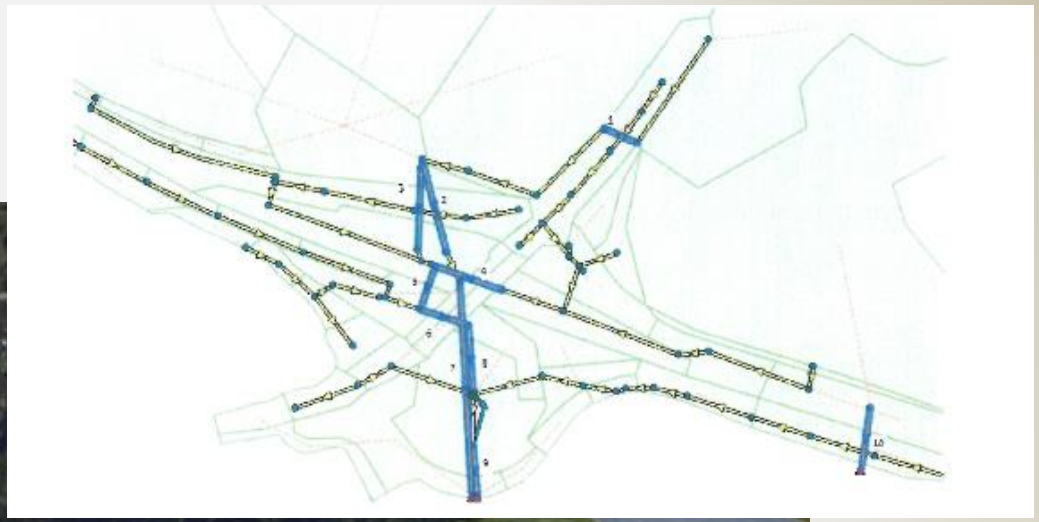
Rev.0

EARLY RESULTS

DESIGN CRITERIAL SHEET REVIEW (CULVERTS, ETC.)

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 - APEGBC recommendations* - Consultant Reports
SCR	5-200yr	+3.6% to +25%	- APEGBC recommendations* - PCIC - IDFCC - Consultant Reports

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 Climate Provider not indicated – future IDF curves

DESIGN CRITERIA SHEET – REVISION

- All Design Criteria Sheets submitted to the Chief Engineer's Office
- Include cost of climate change adaptation design and construction work
- **Example:** Grizzly Creek culvert A-frame prototype trash rack
  - Design cost: $15,000
  - Construction: $40,000–$50,000

CLIMATE CHANGE IMPACT ON NATURAL HAZARDS IDENTIFICATION

- District Development Technicians may identify natural hazard potential. When a potential risk is identified, you may be required to retain a certified professional to provide a report to the Approving Officer
- Approving Officer may refuse to approve the subdivision plan if he or she considers that the land in question may be subject to a natural hazard

CLIMATE CHANGE IMPACT ON NATURAL HAZARDS IDENTIFICATION

Hazards on land to be subdivided include:

- Avalanche
- Flooding
- Erosion
- Landslip
- Wildfire
- Rock fall
- Debris torrent

CLIMATE LANGUAGE PRIMER (RESOURCE)

- Understand concepts, principles and language across disciplines
- When undertaking risk analysis, adaptation, design and operations issues, etc.
- Climate scientists, engineers, hydrologists, facility and structure owners, etc.
- Location:

https://www2.gov.bc.ca/assets/gov/driving-and-transportation/environment/climate-action/climate_data_discussion_primer.pdf

RESOURCES

TRAN Adaptation site

- https://www2.gov.bc.ca/gov/content/transportation/transportation-environment/climate-action/adaptation
- **EGBC Engineering Adaptation site**
- www.egbc.ca/getmedia/1ac17fe9-8eaf-41d3-b095-afac3953b8f3/2017_MoTI-guidelines-06F-web_1.pdf.aspx

PIEVC

- www.pievc.ca/e/index_.cfm

PCIC

- www.pacificclimate.org/

THANK YOU

QUESTIONS?