Government of Saskatchewan
Ministry of Highways
Design and Construction Division

Prairie Runoff Routing and Flood Modelling Tool (PRFMT)
Potential Applications for Ministry of Highways

Hydraulic Design Group

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Potential Applications of PRFMT

1. Flow Rate Estimation of Small Catch Basins (≤ 10 km^2)
2. Risk Based Return Period Flow Rate Estimation
3. Vulnerability Assessment of Hydraulic Structures in Key Corridors (e.g. National Highway Systems)

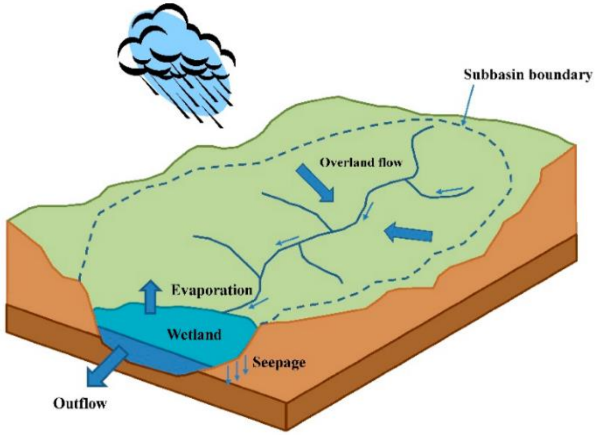
Highways 6 and 16 near Dafoe, SK, Feb. 2015

(photo courtesy of Tetratech)

1. Flow Rate Estimation of Small Catch Basins (≤ 10 km²)

- **Flow Rate Estimation for Basins:**
- Larger than 10 km^2 : Frequency Method by Water Security Agency
- Smaller than 10 km^2: Rational Method

- **Disadvantages of Rational Method:**
- Governance of snow melt rather than rainfall in majority of the runoff in the Prairies
- Not accounting for attenuation effect of depression storage areas
- Being sensitive to runoff coefficient (C) and time of concentration formula



(photo courtesy of Yongbo et al. U of G, 2018)

Client:
Project :
Structure:
IDF Curves: Outlook, PFRA ID: 4055736

RATIONAL METHOD FLOOD FREQUENCY ANALYSIS (1:25)
WITH FUTURE CLIMATE CHANGE PROJECTION

Physical Watershed Charateristics

Parameter	Value	Unit	Reference/Method
Drainage Area (A)	452	hectares	Manually Delineated (using various maps and 20 m DEM).
Highest Elevation	569.7	m	Measured from Geogratis DEM (using Arc-GIS).
Lowest Elevation	564.4	m	Measured from Geogratis DEM (using Arc-GIS).
Watershed Length (L)	1720	m	Measured from Geogratis DEM (using Arc-GIS).
Watershed Slope (S_w)	0.0031	-	Calculated from above watershed length and elevations.
Discharge Coefficient (C)	0.2	-	Assumed Three Different Land Use with 0.31% slope and Soil Group Type C (clay loams and shallow sandy loams).

Time Of Concentration (T_c)

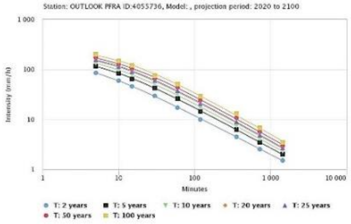
Method	Value	Unit	Formula/Reference
Branscy Formula *for C values of 0.40 or greater	169.10	minutes	$T_C = \frac{0.057\,L}{S_w^{0.2}.A^{0.1}}$
Airport Formula *for C values less than 0.40	820.23	minutes	$T_C = \frac{3.26.(1.1-C).L^{0.5}}{S_w^{0.33}}$
TOC Used	820.23	minutes	Airport formula was used for C= 0.2

Design Discharge (Q)

Parameter	Value	Unit	Reference/Method
Return Period	25	years	Applied to Cross Drain Design
Projected Rainfall Intensity (i)	4.376	mm/hr	Determined from Regional IDF Curve (below)
Projected Design Discharge (Q)	1.1	m^3/s	$Q = 0.0028\,.\,C\,.\,i\,.\,A$

IDF Graph: Intensity – GEV – RCP 8.5

Station: OUTLOOK PFRA ID:4055736, Model: , projection period: 2020 to 2100



RAINFALL INTENSITY CALCULATION

$i(mm/h) = A.\,(t+t_0)^B$

Coefficients for the interpolated equations fitted to the average IDF for 1:25 years return period with future scenario RCP 8.5 using the GEV distribution;
A= 40.4 , B= - 0.847 , t_0= 0.123

CLIMATE CHANGE PROJECTION

Using the IDFCC tool, the future climate simulation of the Outlook rainfall station shows an increase in precipitation by up to 4.8 % for the 2100's time horizon. Ensemble median of GCM-CanESM2 is used as Climate Mode assuming a Representative Concentration Pathway (RCP) 8.5 climate change scenario.

2. Risk Based Return Period Flow Rate Estimation

Current Flow Rationalization Method:

- Historical performance of a crossing (not always available)
- Capacity of existing and previous structures at the crossing
- Flow rates from frequency analysis (by WSA)

Alternative Method (using PRFMT) :

- Simulation of a detailed physically-based hydrology model for a catch basin
- Assessment of historical and future high flow events
- Determination of return period for subject hydraulic structure based on ***performance risks*** (overtopping, flooding, etc.)

Advantage:

- Compensation for lack of historical data
- Accounting for changes in climate and land use
- Preventing from basin transfer errors (e.g. relative basin sizes, sloughs, etc.)
- Providing an optimum design (efficient cost of construction)

Table 502-1: Culvert Design Flow Frequencies

Class of Road	Design Frequency (Instantaneous Peak Flow)
National Highway System	1/50
All Other Provincial Highways & Provincial Roads	1/25
Other Roads	1/5 to 1/10

Table 502-2: Bridge Design Flow Frequencies

Class of Road	Design Frequency (Maximum Mean Daily Flow)
Provincial Highways and Provincial Roads	1/50 to 1/100
Other Roads	1/25

(Design Flow - HM 502-00)

3. Vulnerability Assessment of Hydraulic Structures in Key Corridors

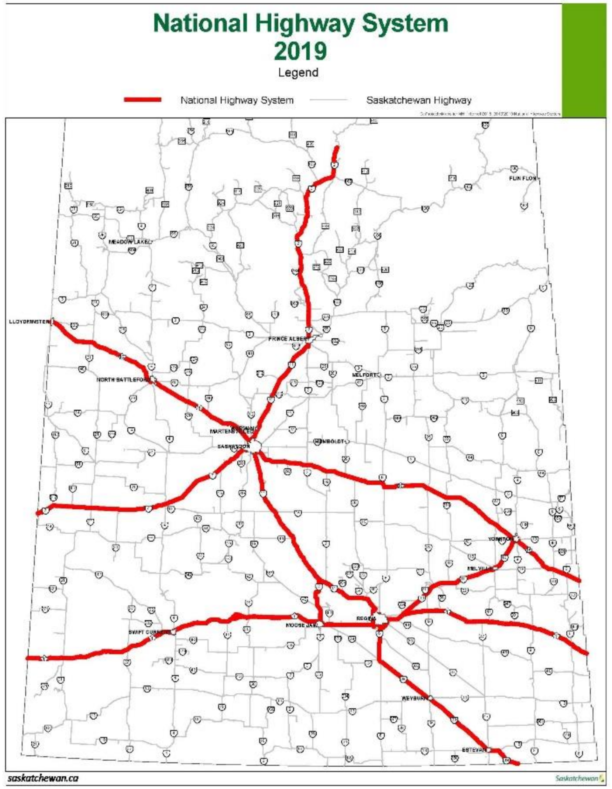
Question:

- How resilient our physical assets are against future flood events?
- Do we have resiliency or vulnerability indices for our key infrastructure ?

Vulnerability Assessment of Structures:

- Simulate flood sensitive crossings using PRFMT
- Assess climate vulnerability index (capacity/load) for infrastructure in extreme events

Highway 01, Culvert Crossing Near Maple Creek, SK
Flood Event 2010



The storm washed away part of the Trans-Canada Highway, requiring about $10 million in repairs (CBC News, June 2010)

THANK YOU

FOR YOUR ATTENTION

QUESTIONS ?