KGS GROUP

The Pas Flood Hazard Mapping Study

Melissa Haresign, M.Sc., P.Eng.

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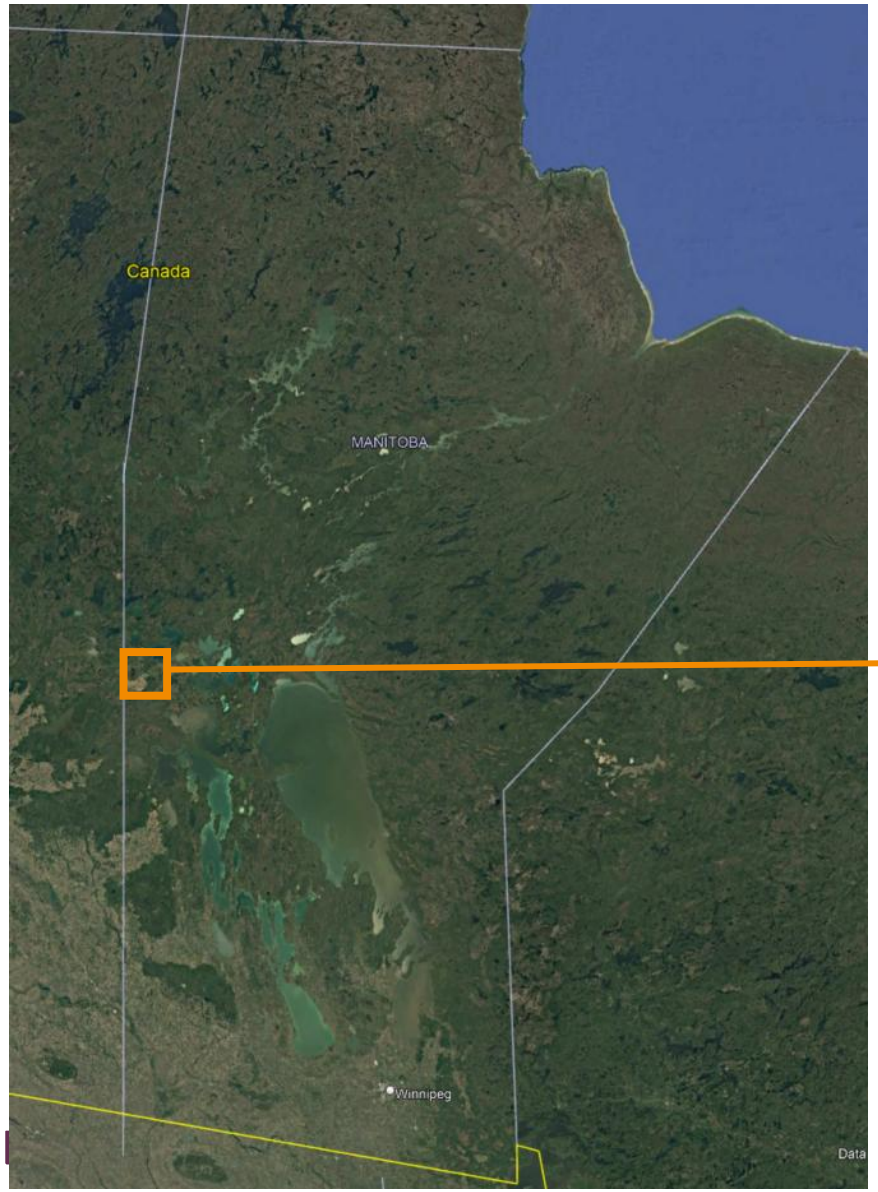
Background

- The Pas is located in northern Manitoba at the confluence of three rivers: Saskatchewan, Carrot and Pasquia rivers.
- River geometry and flat, deltaic watershed contribute to regular flooding in the area, both under spring runoff and ice jam conditions.
- Hydraulic modelling and flood mapping was required to better understand flood extents at The Pas under both open water and ice jam conditions.

Study Area


Canada
MANITOBA
Winnipeg


N
KGS
Saskatchewan River
Birch River
Moose
Park
Opaskwayak
Cree Nation
Big Bend
Rall's
Island
The Pas
Sapaskoo Creek
Carrot River
Pasquia Farming District
Culdesac River
Pasquia River
Pump Station
Dam
River
Tributary
Drain
Dike

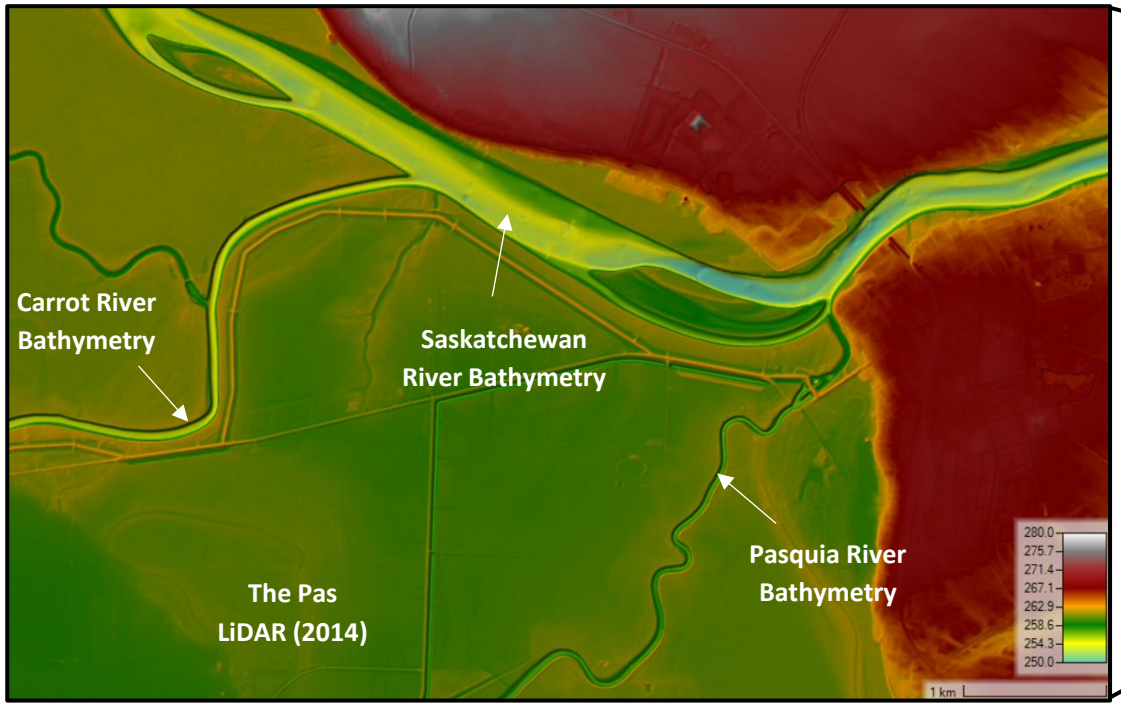
Available Survey Data

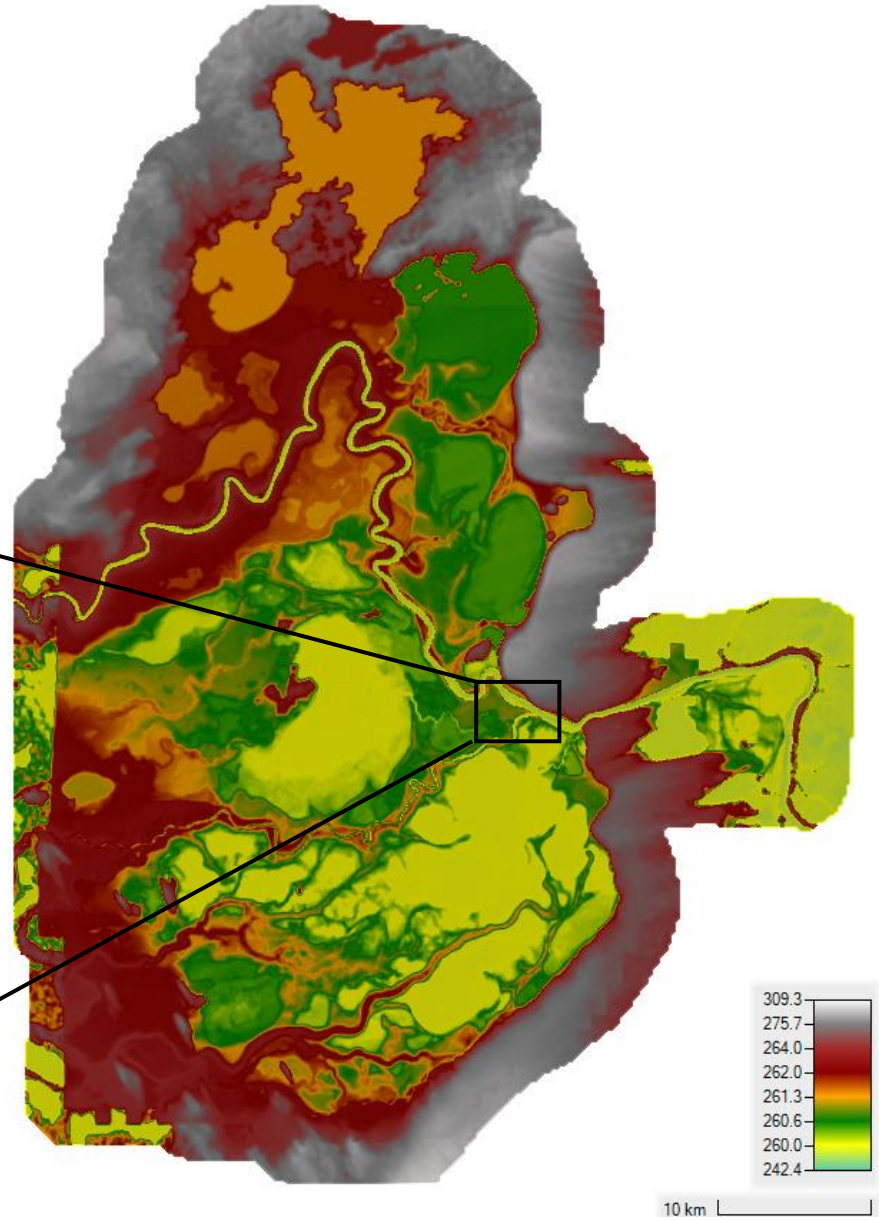
LiDAR

River Cross Sections

Digital Elevation Model

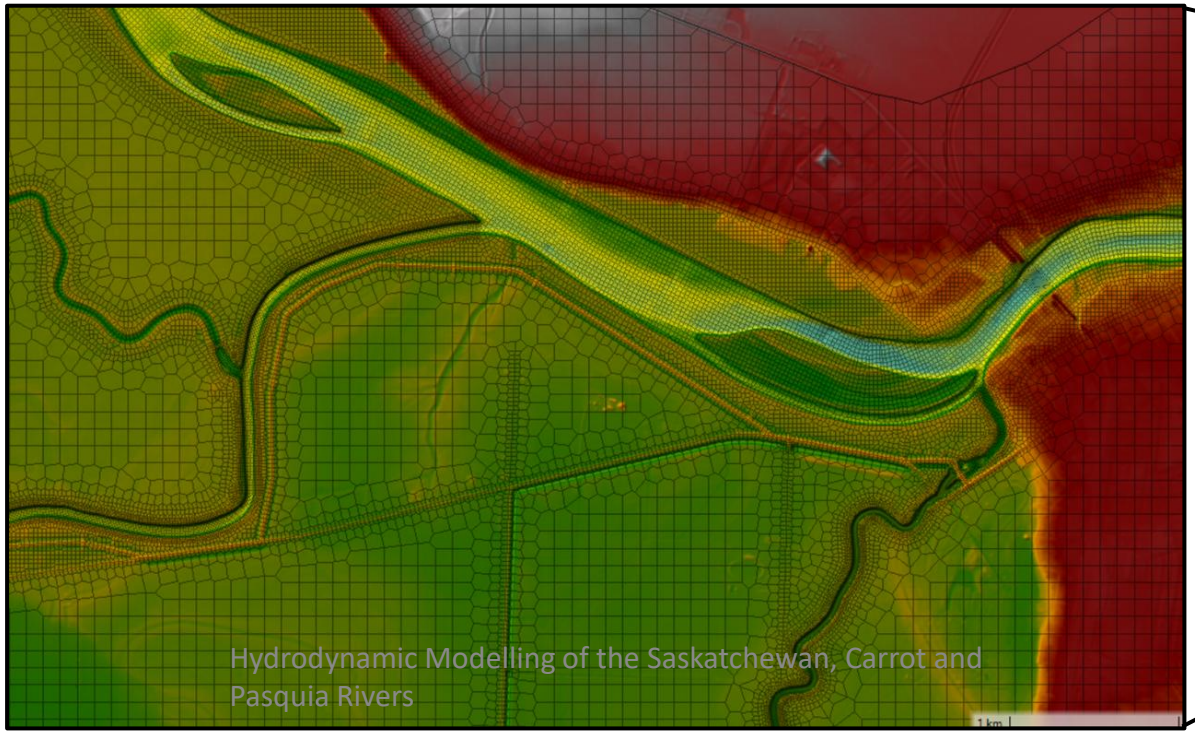
- All LiDAR and river cross sections were merged into a continuous, seamless DEM that was integrated into the hydraulic model

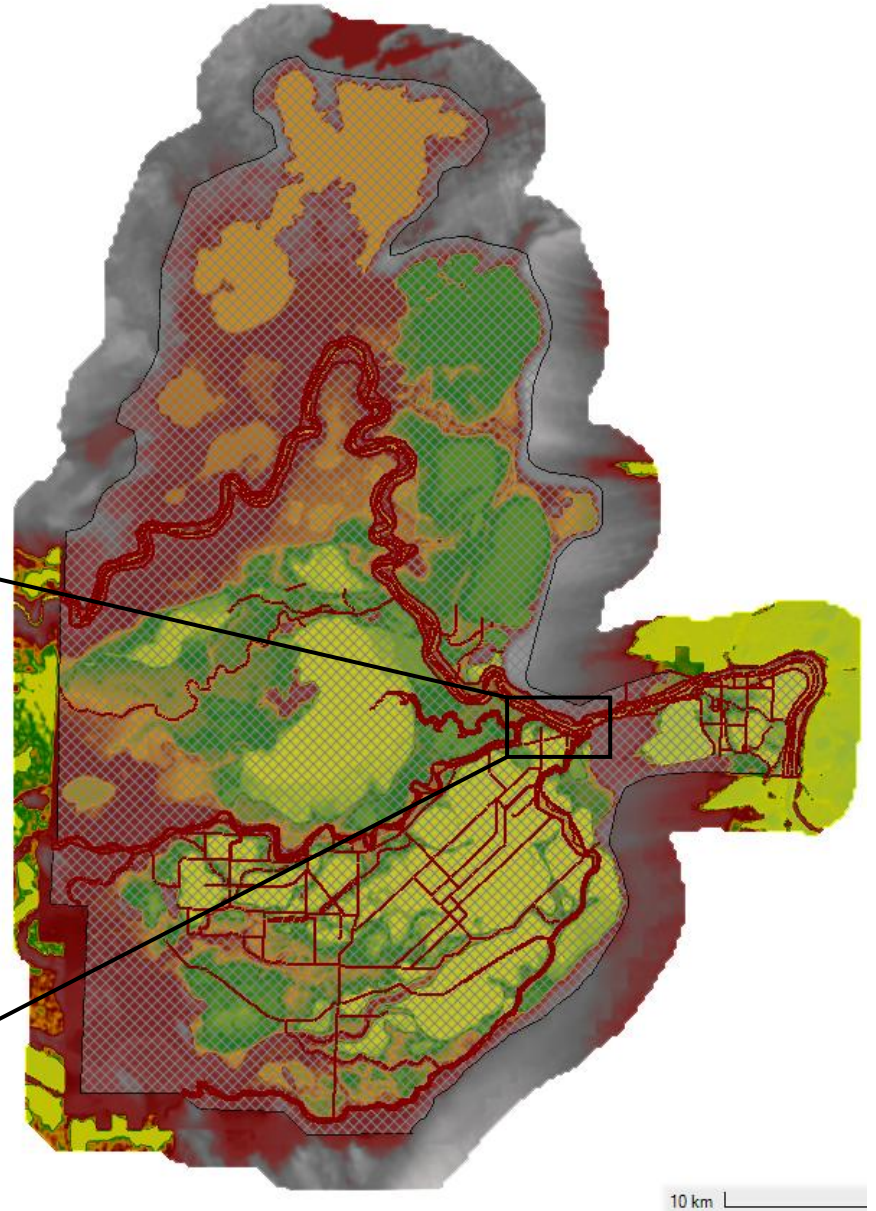




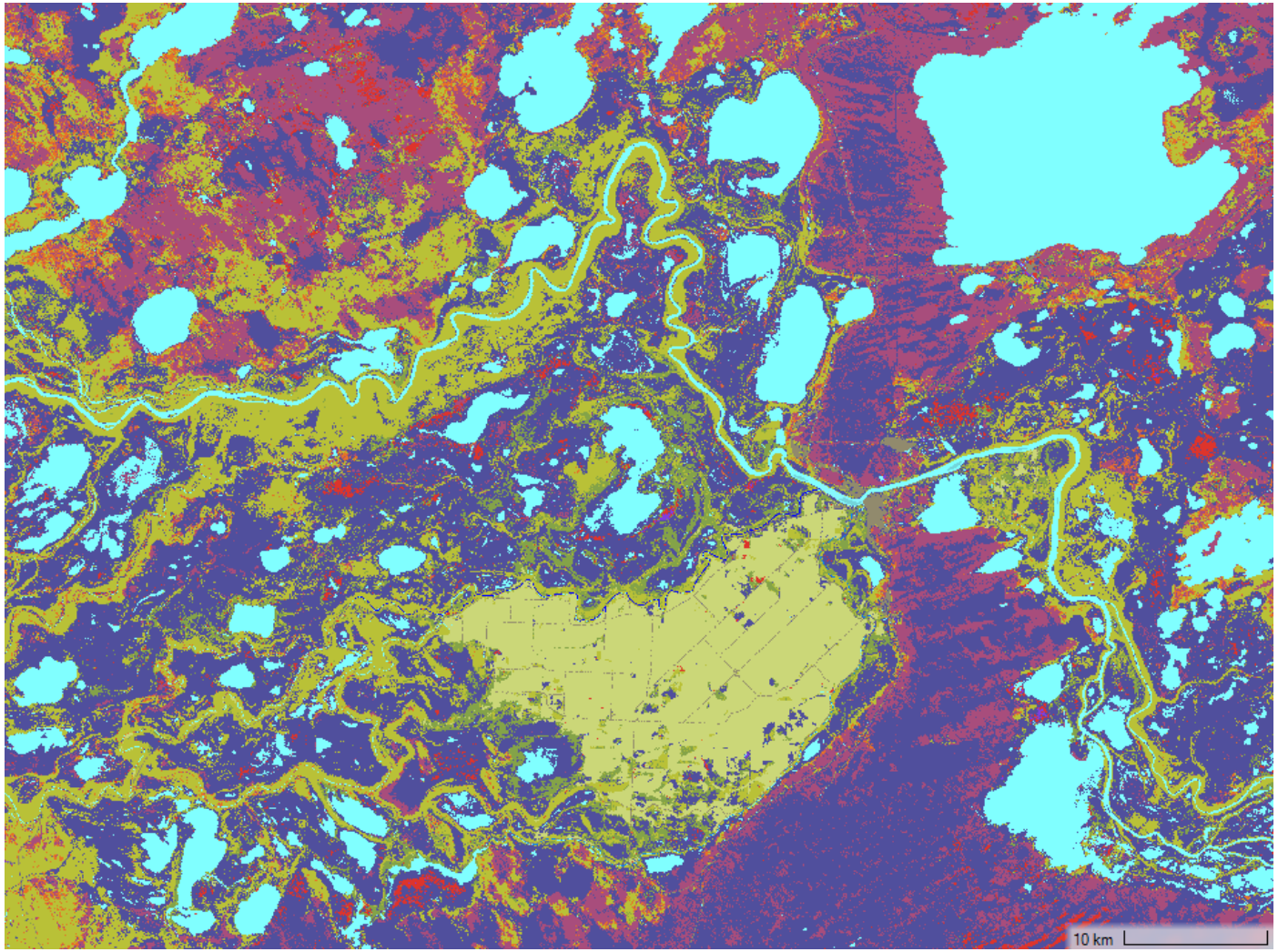
Hydraulic Model Development

- 2D HEC-RAS model was developed to model open water conc
  - Saskatchewan, Carrot and Pasquia rivers
  - Various tributaries and agricultural drains
  - Control structures
- 2D model domain based on 500-year flood extent





Hydraulic Model – Roughness Coefficients

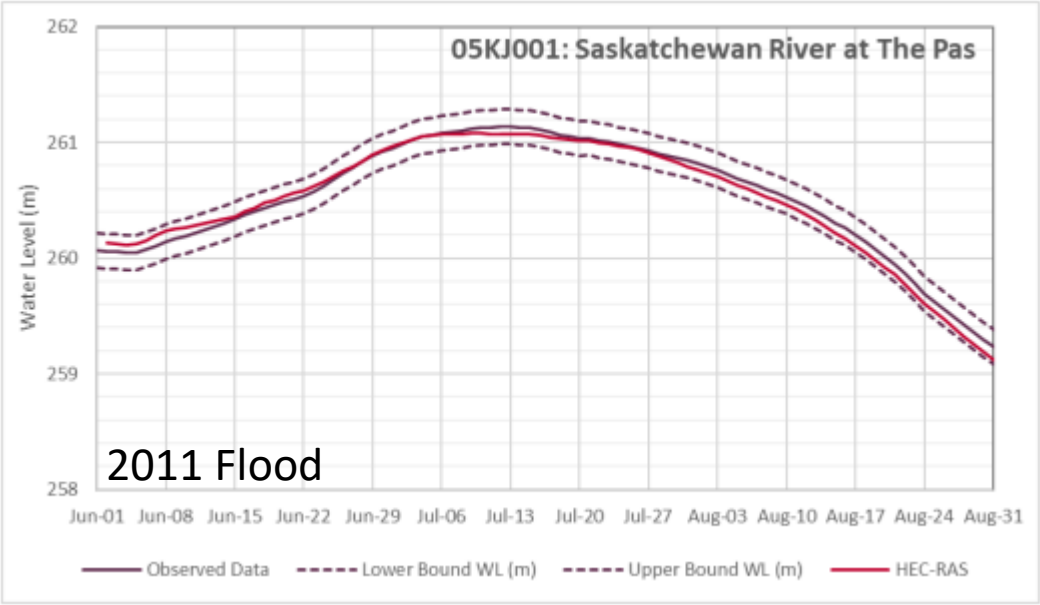


Land Use / Area	Adopted Manning's n
Saskatchewan River Channel	0.020 – 0.038
Carrot River Channel	0.032 – 0.046
Pasquia River Channel	0.038
Forest	0.060
Shrubland	0.050
Grassland/Cropland	0.040
Barren, Urban and Built-up	0.020
Wetland	0.040
Water	0.032

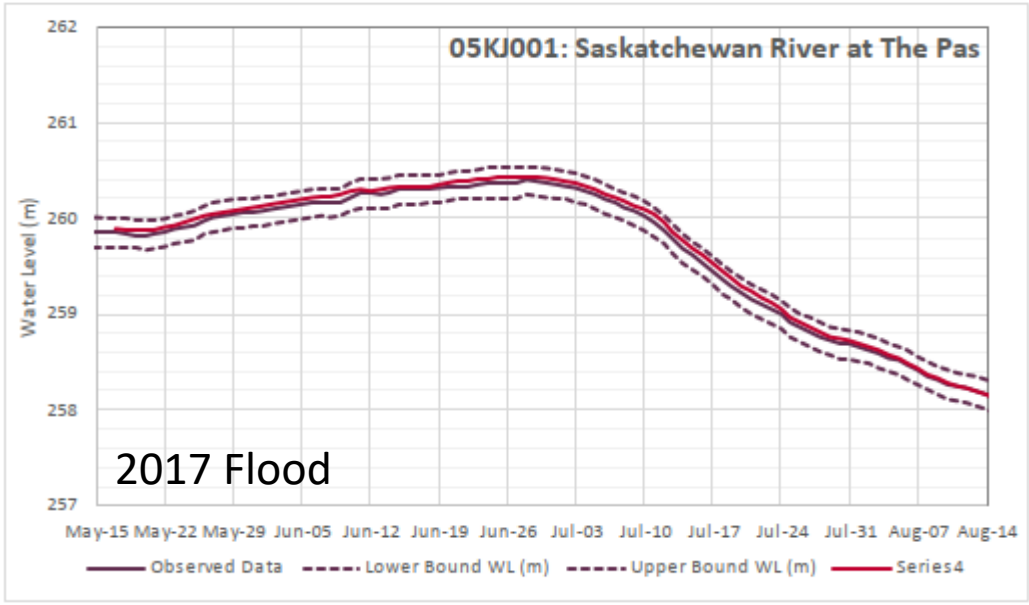
Hydraulic Model - Inflows

- Inflows to the model defined by:
  - Inflows at upstream end of key rivers
  - Inflows at confluence points of key tributaries
  - Inflows at pump stations
- Calibration flows defined by:
  - Recorded flows on Saskatchewan and Carrot rivers
  - inflows on ungauged tributaries defined by proration
  - Pasquia river inflow defined by trial and error

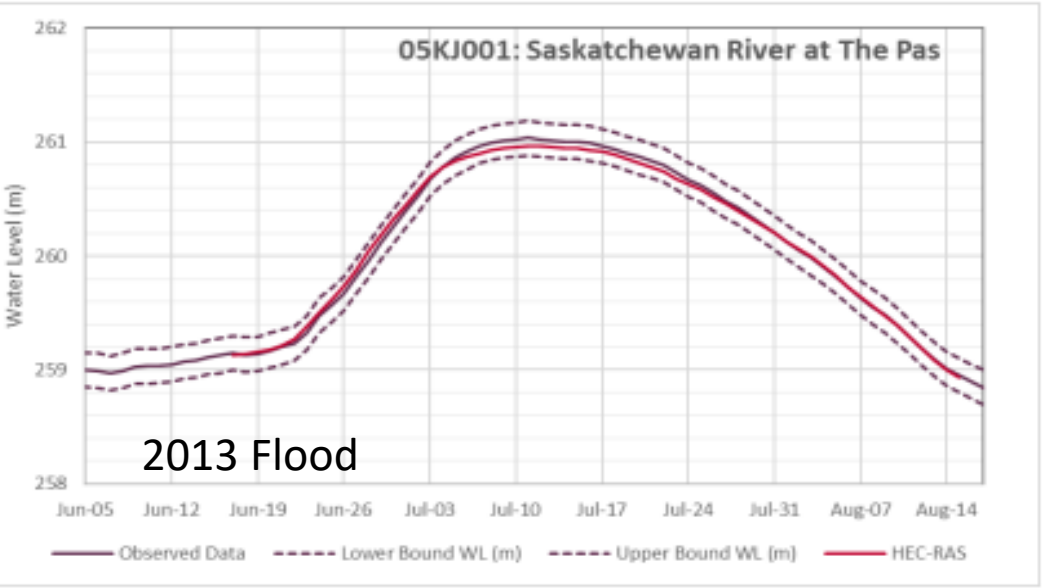
Hydraulic Model Calibration



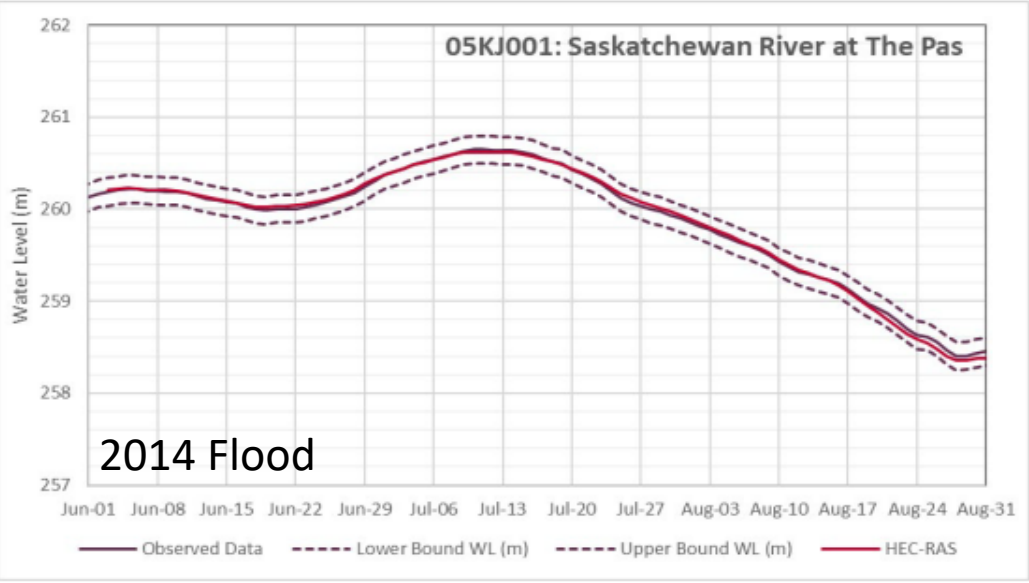
2011 Flood



2017 Flood



2013 Flood

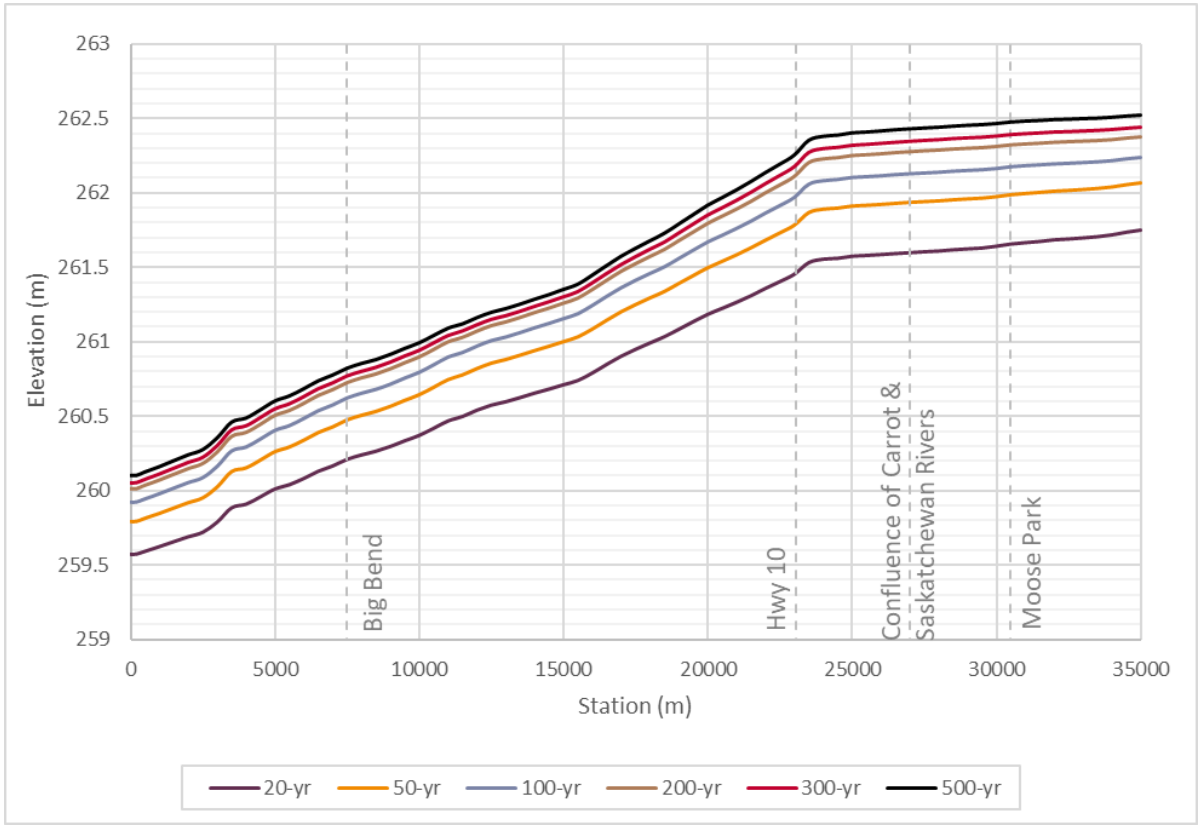


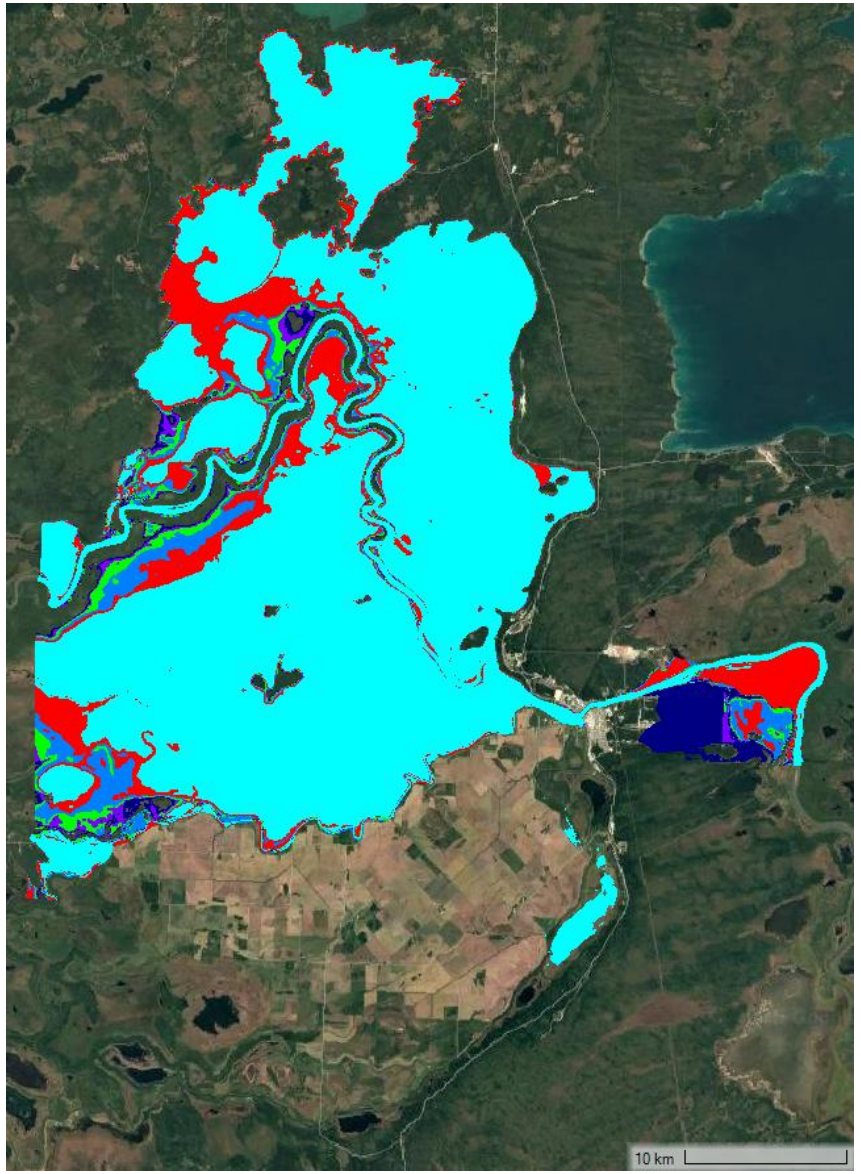
2014 Flood

Open Water Return Period Floods

Steady-state simulation of:

- Flood frequency flows on the Saskatchewan River
- Coincident flows on Carrot River
- Maximum pump station capacity





Ice Jam Modelling - Challenges

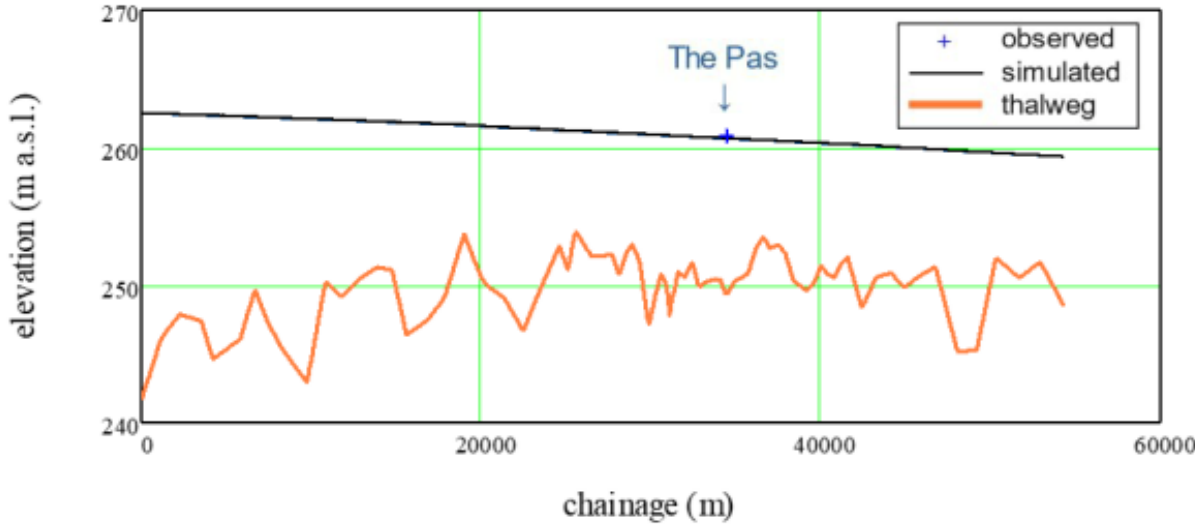
- Ice dynamics are highly variable, and predicting how ice will behave in a river under changing conditions can be challenging.
- Extensive field data for calibration is not available. Judgement is often required.
- HEC-RAS requires explicit definition of ice jam parameters, which are typically unknown
- Joint probability must be considered

Ice Jam Modelling - Solutions

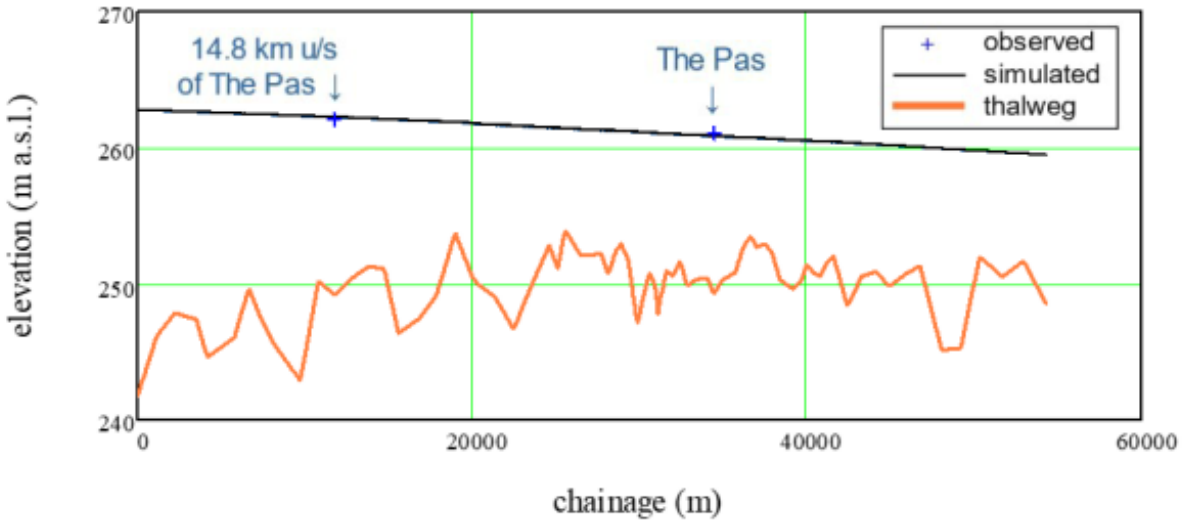
- Used RIVICE model combined with a Monte Carlo Analysis
- RIVICE:
  - 1D model designed to simulate ice processes in rivers
- Monte Carlo Analysis:
  - Technique used to understand the impact of uncertainty and variability in a model or system
  - It involves running many simulations to generate a range of possible outcomes and assess the likelihood of different results.

Ice Jam Modelling - RIVICE Calibration

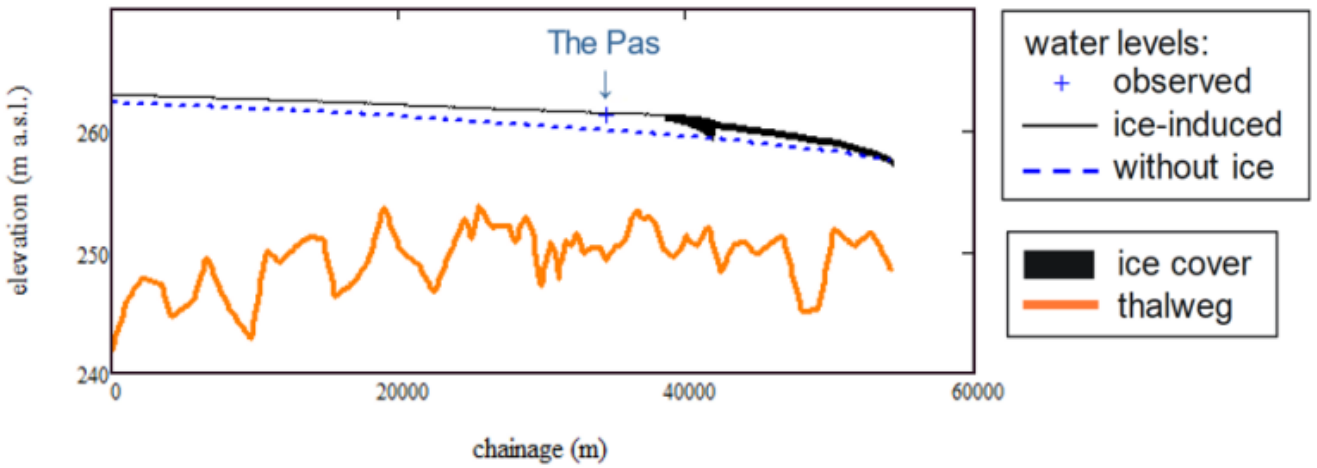
2005 Open Water Flood



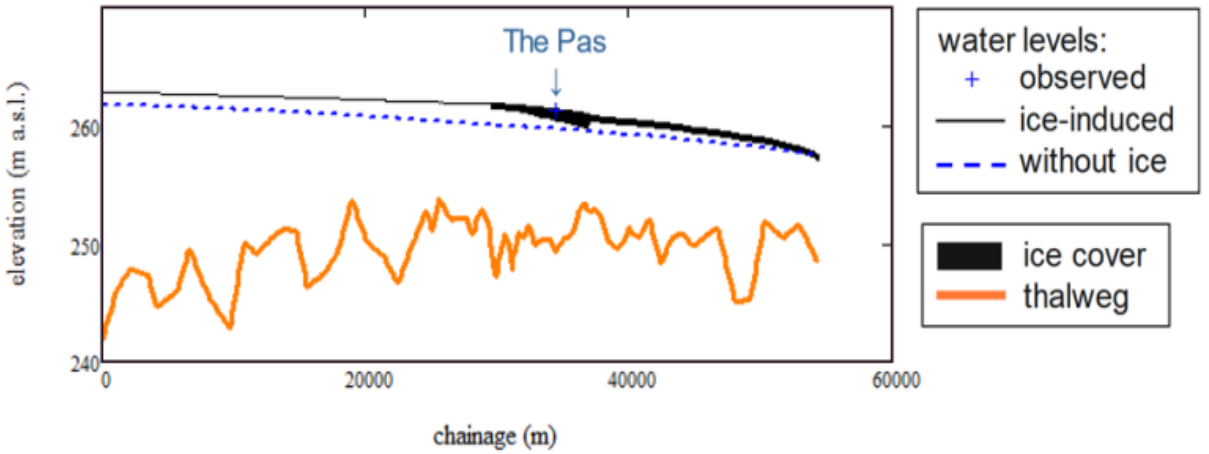
2013 Ice Jam Flood



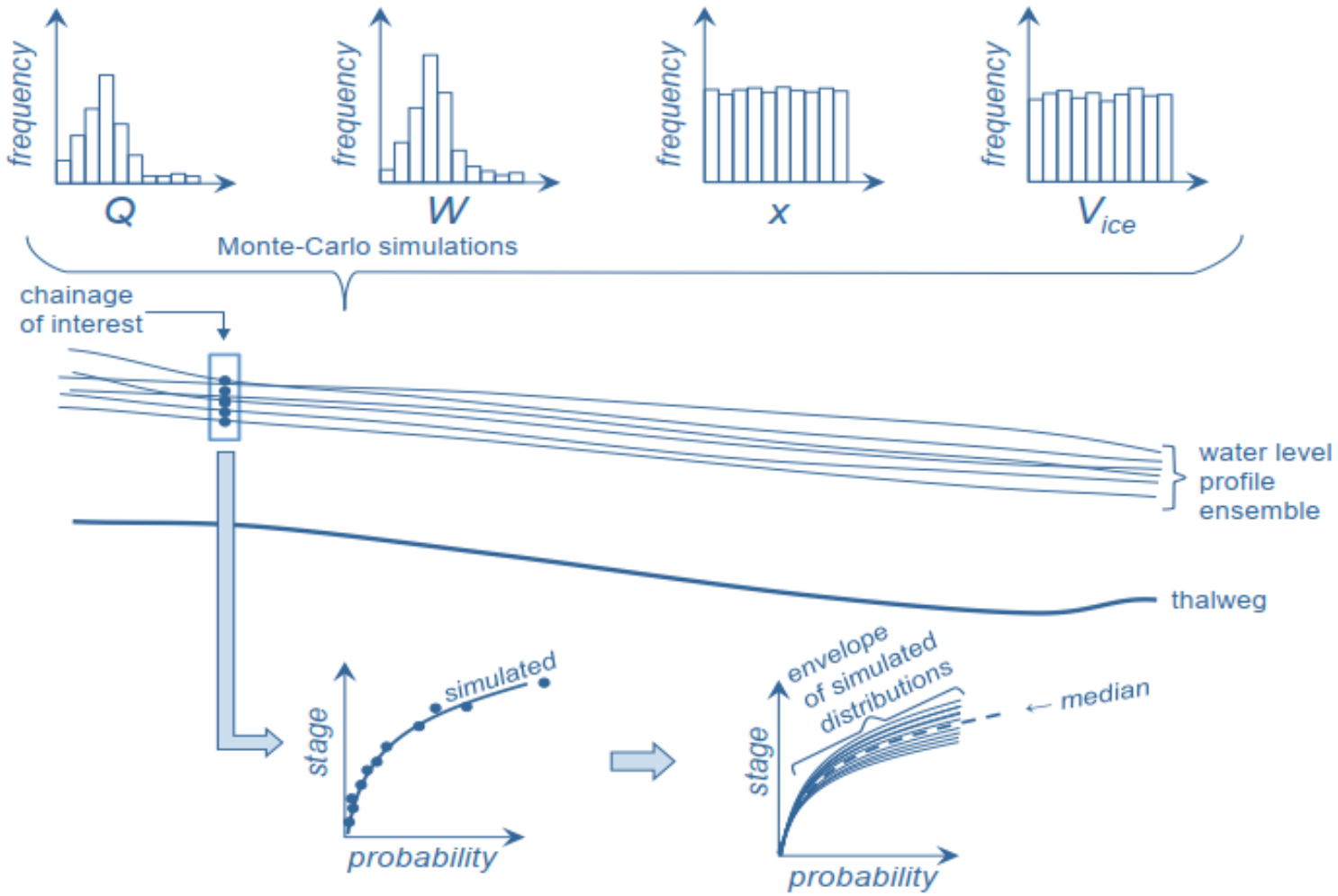
2014 Ice Jam Flood



2017 Ice Jam Flood



Ice Jam Modelling – Monte Carlo Analysis



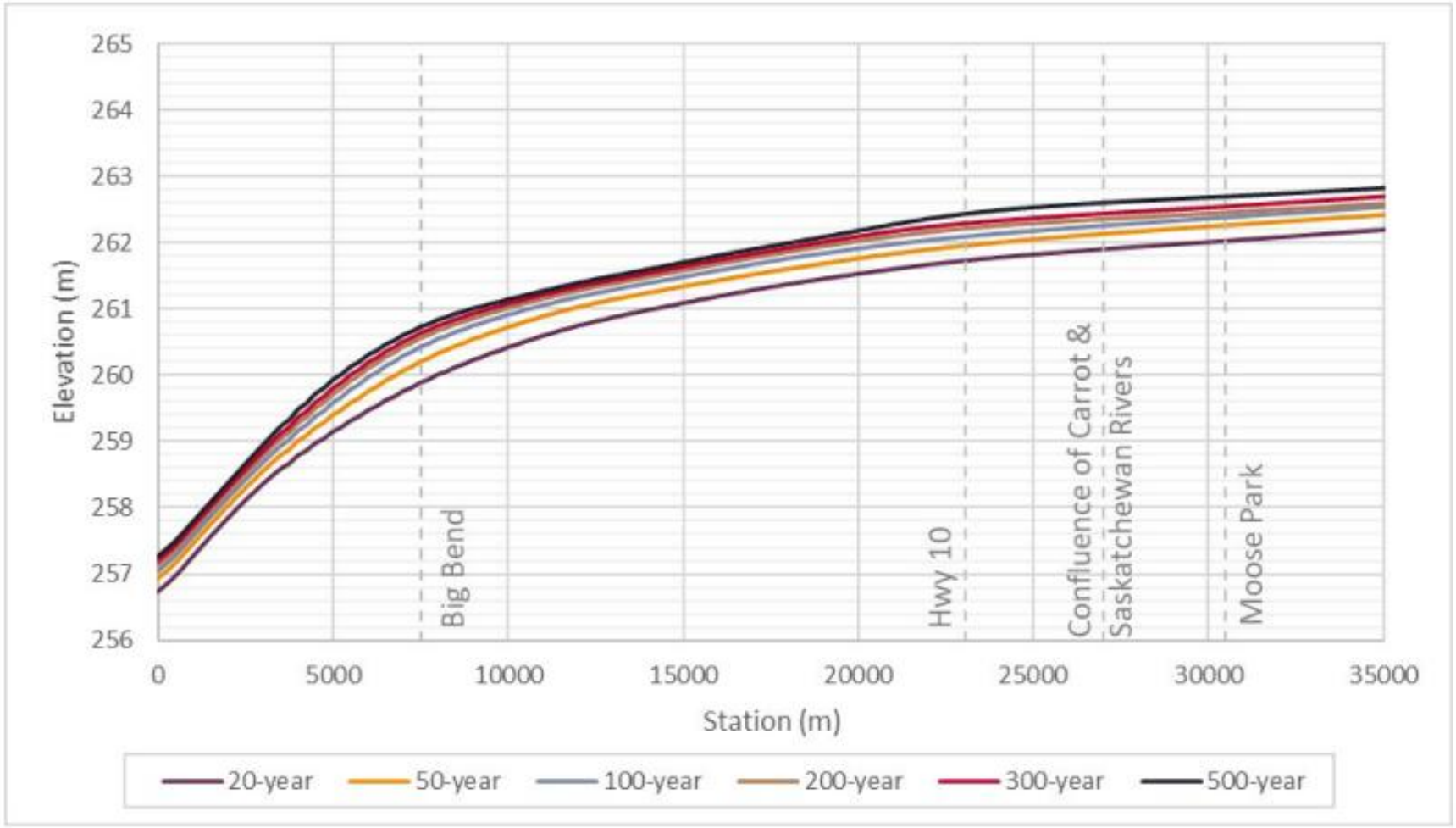
Ice Jam Modelling – RIVICE Parameters

Parameter	Minimum	Maximum
Rubble Ice:		
Rubble Ice Porosity	0.45	0.55
Thickness of Rubble Pans (m)	0.55	0.65
Ice Jam Cover:		
Volume of Incoming Ice / Time Step (10^6 m^3)	5	85
Ice Cover Front Porosity	0.45	0.55
Thickness of Ice Cover Front (m)	0.55	0.65
Ice Jam Lodgment:		
Thickness of Ice Downstream of Jam (m)	0.65	0.75
Cross-section number of Lodgment	325	515
Ice Transport:		
Ice Deposition Velocity (m/s)	1.1	1.3
Ice Erosion Velocity (m/s)	1.7	1.9
Hydraulic Roughness:		
Ice Roughness Coefficient* ($s/m^{1/3}$)	0.065	0.12
Channel Bed Roughness ($s/m^{1/3}$)	0.027	0.029
Strength Properties:		
Lateral : Longitudinal Stresses	0.15	7.30
Longitudinal : Vertical Stresses	0.22	7.52

*Ice roughness for an 8 m thick ice layer, corresponds to a roughness of approximately 0.028 – 0.051 for a 1 m thick ice layer.

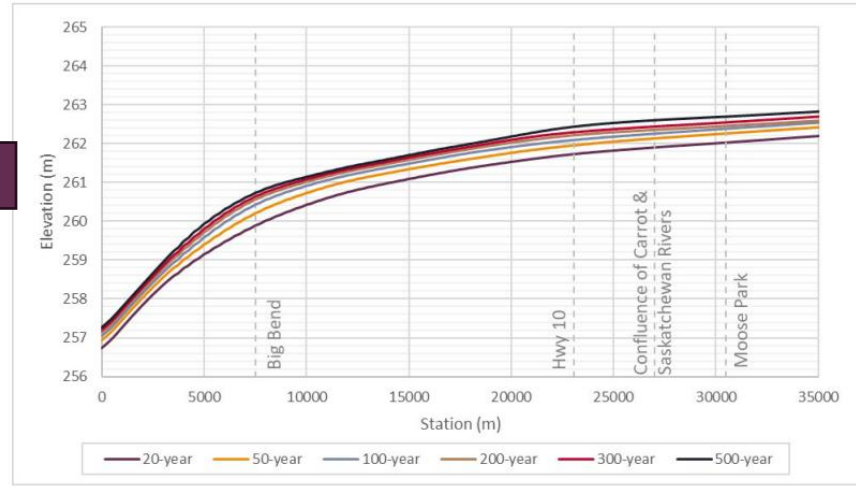
Ice Jam Modelling – Ice Jam Profiles

- Extracted the profiles corresponding to flood events of interest from the Monte Carlo suite of profiles.



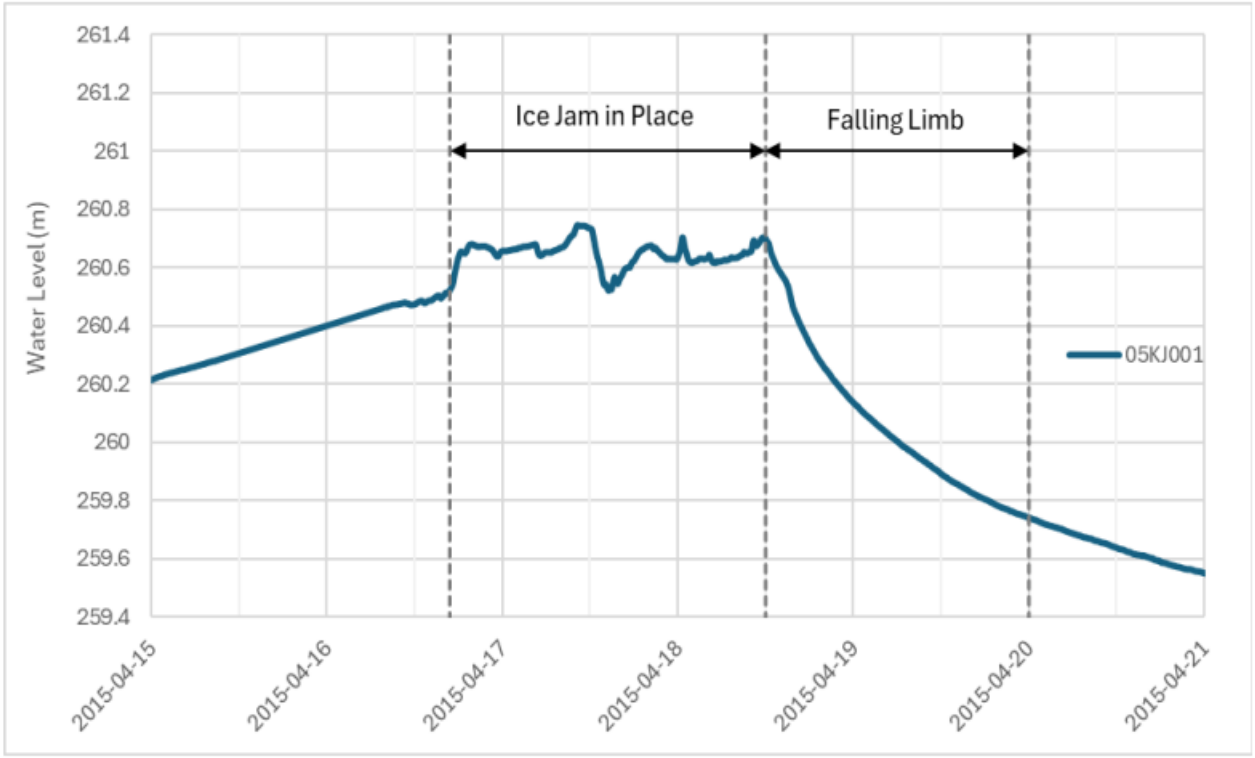
Ice Jam Modelling – Flood Extents

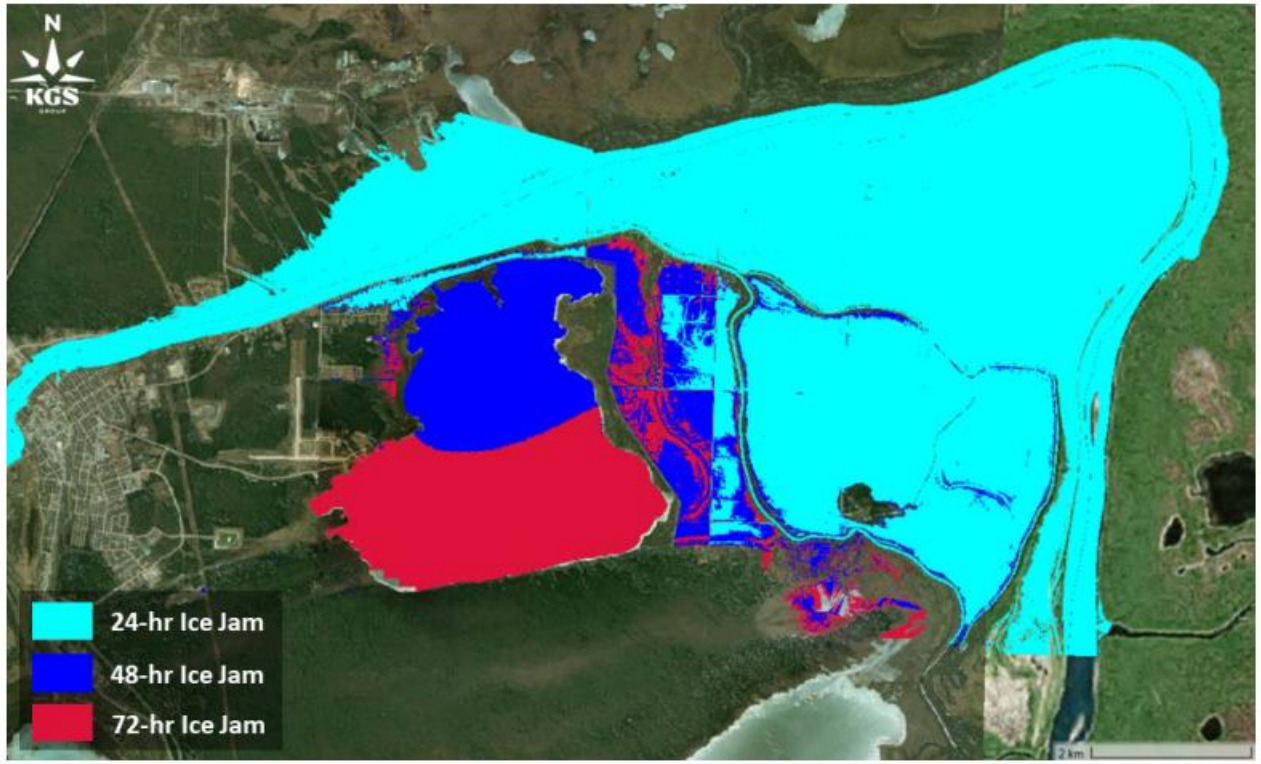
- Used 2D HEC-RAS model to simulate ice jam profiles in model domain to evaluate extent of flooding



Ice Jam Modelling – Flood Extents

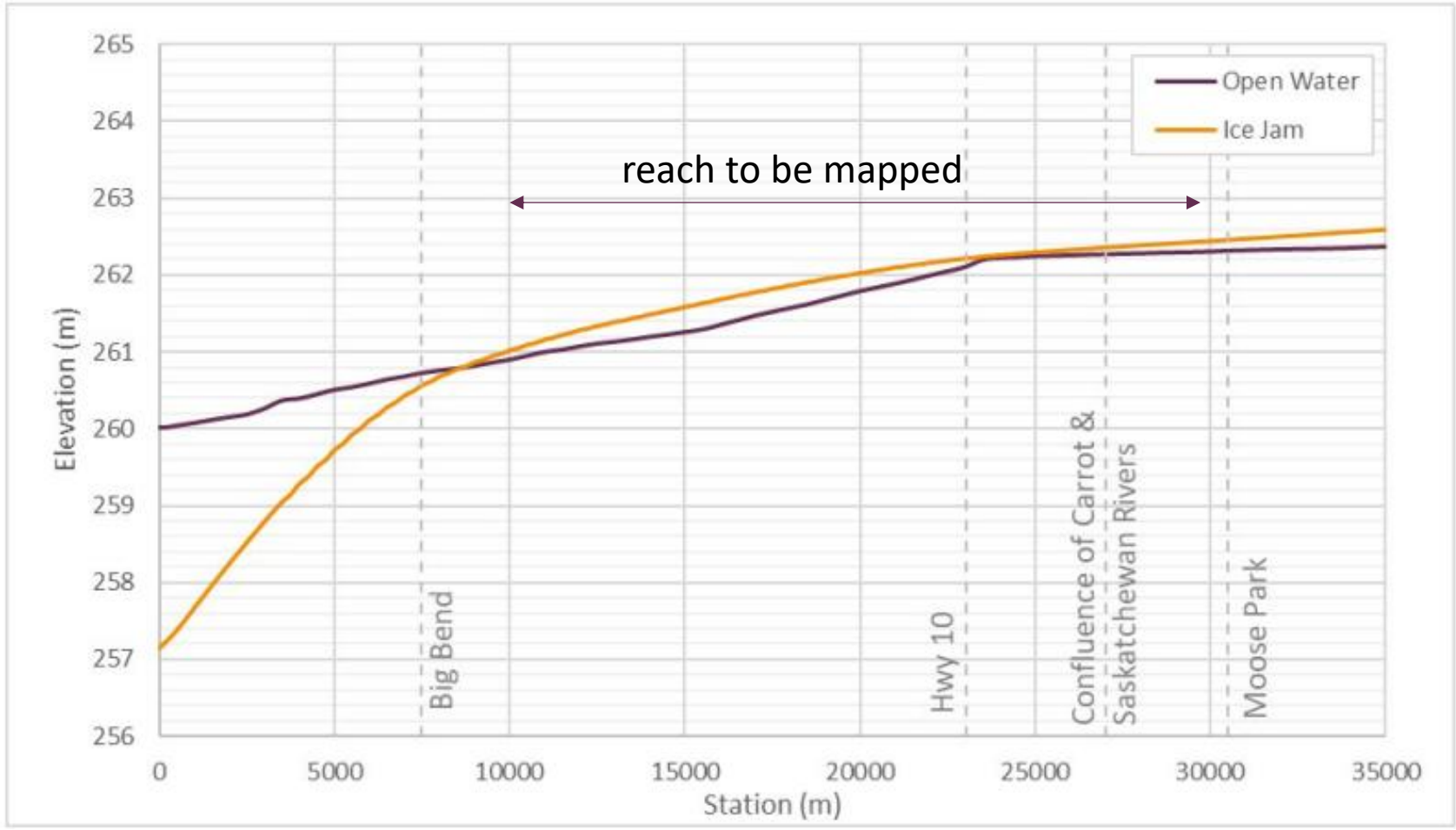
- Need to define duration of ice jam is in place to estimate flood extents
- Reviewed historic ice jams data to determine typical duration
  - Most recorded ice jams were approximately 2 days in duration
- Sensitivity analysis completed using longer and shorter durations





200-Year Flood Comparison

- Ice jam flood levels governed within The Pas



Flood Hazard Maps

- Flood hazard maps were developed for the 200-year flood showing the maximum of the open water and ice jam floods
- Flood mapping data will inform flood hazard across a broad range of flood events
- Flood hazard data will enhance Manitoba's flood mitigation and emergency response

Questions?

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Thank you!

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