Public Safety Canada | Sécurité publique Canada

BUILDING A **SAFE** AND **RESILIENT CANADA**

Data Science and Engineering at Public Safety Canada

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Canada

Public Safety Canada (PS)

Public Safety Canada has the mandate to keep Canadians safe from a range of risks such as natural disasters, crime and terrorism; and direction to further incorporate the use of science across all elements of emergency preparedness.

In December 2021, Bill Blair was appointed Minister of Emergency Preparedness within Public Safety and was given a mandate in several key areas of flood hazard and risk management. The Current Minister of Emergency Preparedness is Harjit Sajjan.

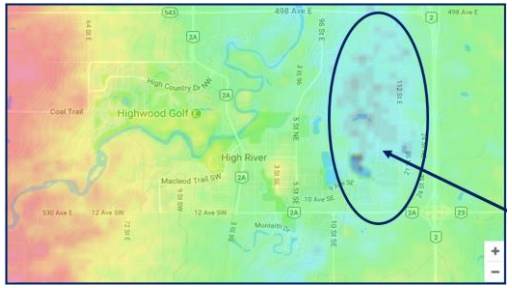
In April 2023, the Government of Canada Budget 2023 described specific actions for Public Safety to take regarding flood risk and resiliency. Budget 2024 reiterated key priorities.

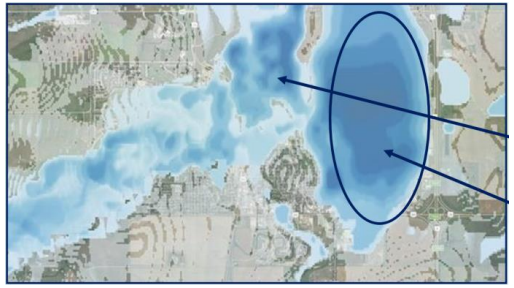
Natural Hazard Risk Management: Federal Programs

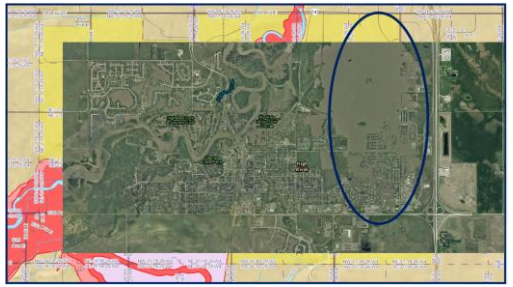
- Flood risk reduction is a joint responsibility of all levels of government.
- PS is advancing several flood risk reduction initiatives:
  1. Implement a **modernized DFAA Program**, which would incentivize mitigation efforts
  2. Stand-up a low-cost **Flood Insurance Program** aimed at protecting high-risk households
  3. Identify **Federally Identified Flood Risk Areas (FIFRA)** for federal government purposes
  4. Create a publicly accessible online Flood Risk Awareness **Digital Resource** for Canadians

Context: How much of a problem is flooding?

- Flooding is Canada's **costliest** natural hazard, and climate change is projected to increase the frequency, severity and variability of all types of flooding.
- Total residential flood risk in Canada is estimated at **$2.3 billion** per year of Average Annual Loss.
- Canada's exposure to flooding is **growing** as a result of shifts in precipitation extremes and increasing housing, infrastructure development, and asset concentration in flood-prone areas.
- A significant number of Canadians located in high-risk flood areas **are not aware of their home or property being at risk**, which is a barrier to effective risk reduction.







Flood Hazard Mapping and Modelling

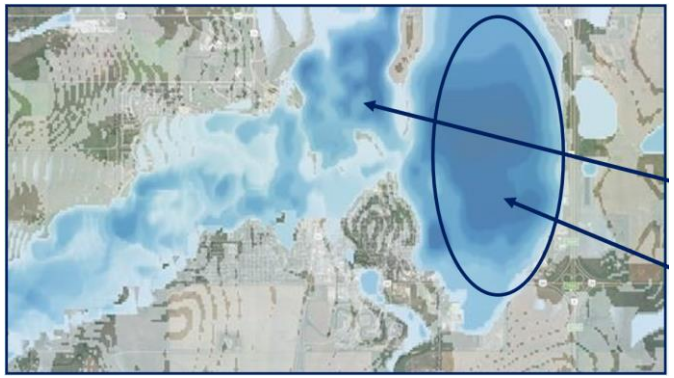
- Flood mapping **improves** the overall understanding of flood risk and supports flood management response.
- The current flood mapping landscape in Canada includes two main types of flood mapping:

Engineering flood maps

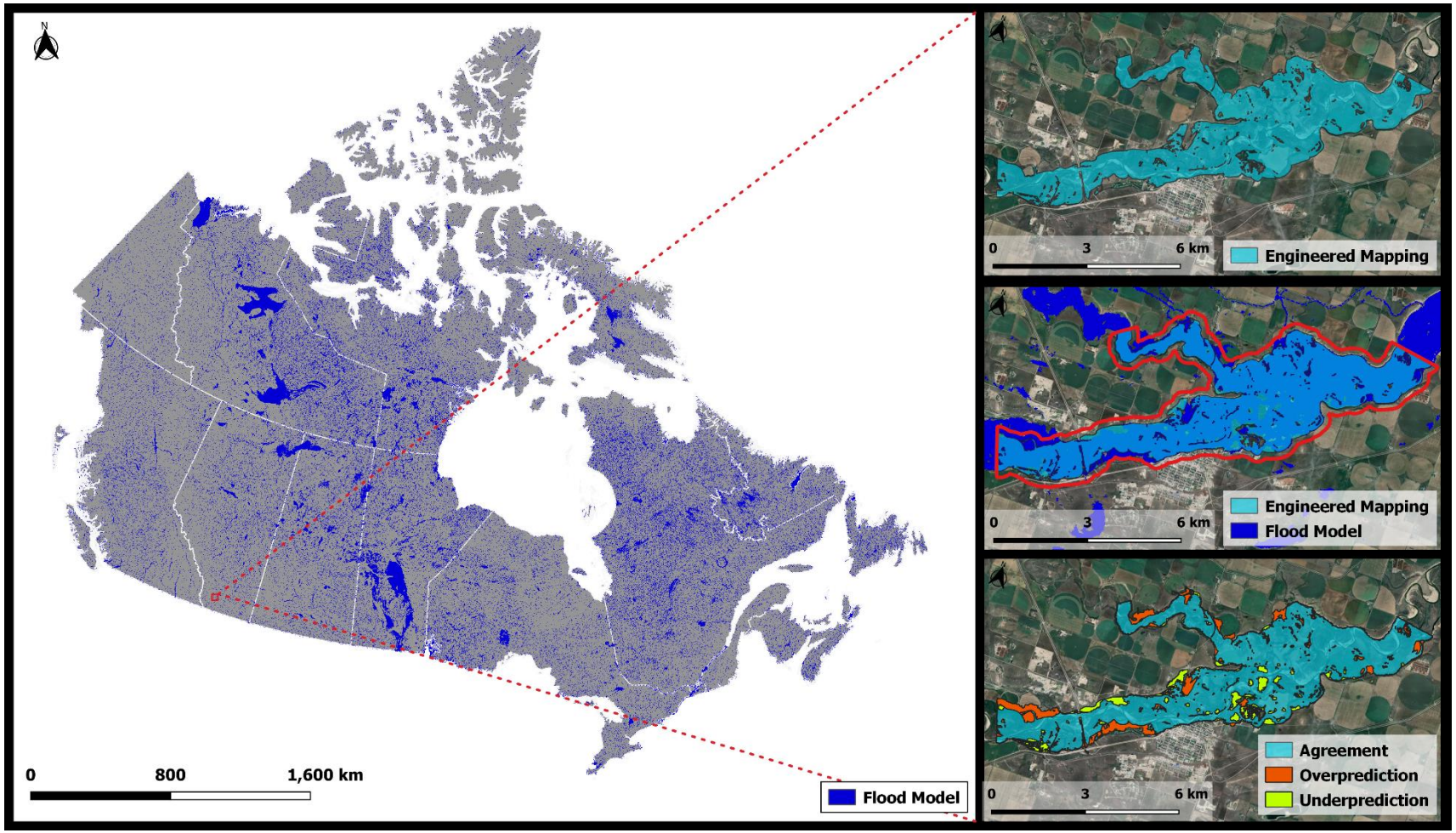
- 'Typical' Flood Maps in Canada
- Use high resolution input data
- Consider regional hydrology and local hydraulic features
- Produce maps of (relatively) high accuracy and precision.

Global modelling and mapping

- Are lower resolution (~30m)
- Estimate pluvial, fluvial, and coastal flood extents and depths
- Provide depth and extents for a variety of return period
- Are relatively low accuracy and precision



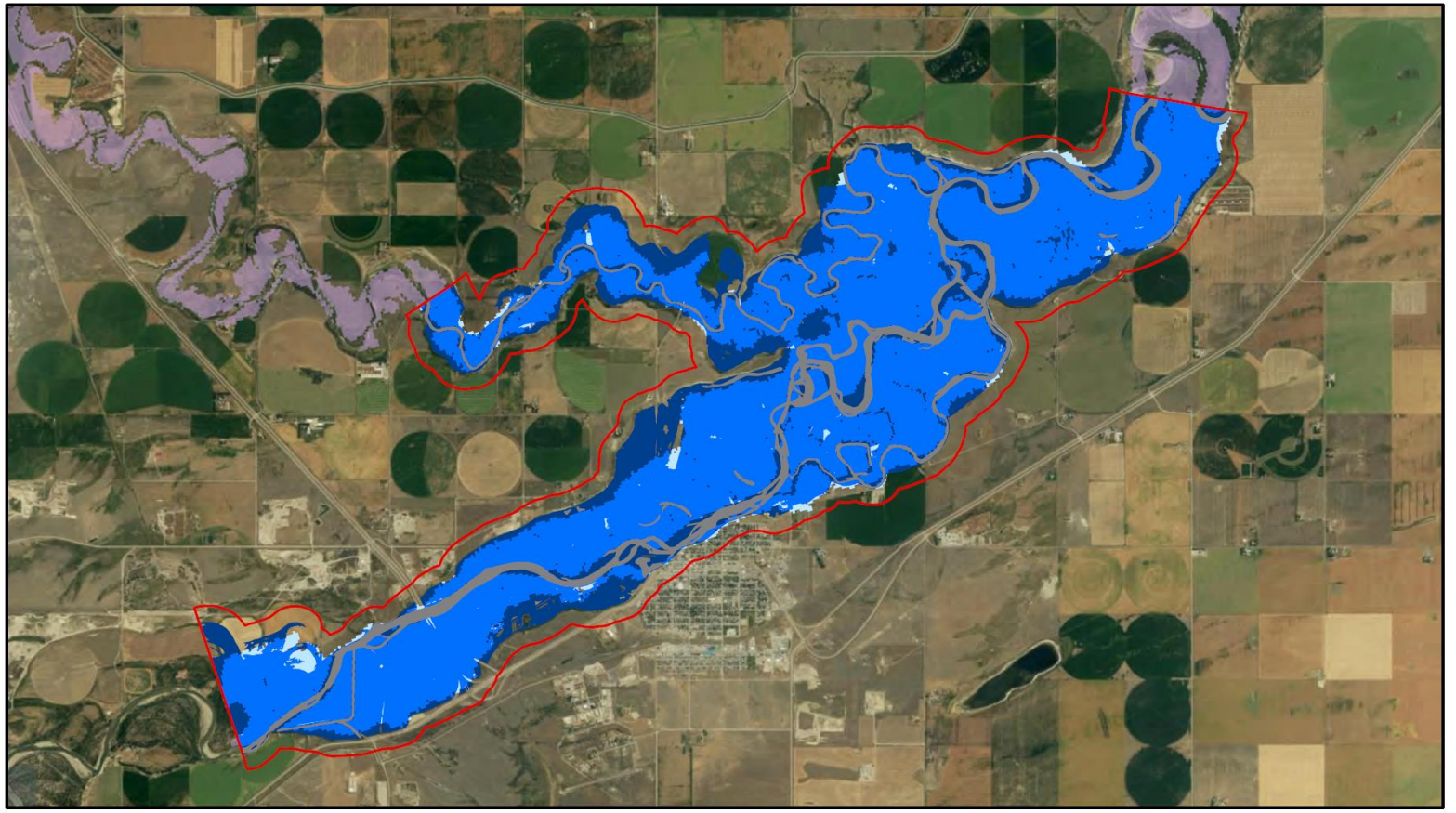
How do the models compare?



(Left) national coverage flood hazard modelling (JBA Risk Management, 2020); (Upper-right) engineered flood hazard mapping conducted at Fort MacLeod (Province of Alberta, 2020); (Lower-right) the same area as the engineered site (bordered in red) showing continuity of coverage with flood modelling.

Model Evaluation Results: Aon

RESILIENT CANADA



Comparison of Aon Flood Hazard Area and Reference Map Flood Hazard Area
For Fort MacLeod, Alberta: 500 Year Fluvial Return Period

Study Area
Waterbodies

1.8% Aon Modelled Flood Hazard Area outside of Reference Map Flood Hazard Area
77.2% Reference Map Flood Hazard Area captured by Aon Modelled Flood Hazard Area
22.8% Reference Map Flood Hazard Area not captured by Aon Modelled Flood Hazard Area
Aon Modelled Flood Hazard Area outside Study Area

0 0.4250.85 1.7 Km

N

Reference Map Source: Alberta Environment, 2020
Waterbodies: DMTI Spatial
Core\Analysis.gdb\Albers\ALT_IOW_0500Y

Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Critical Success Index Calculations

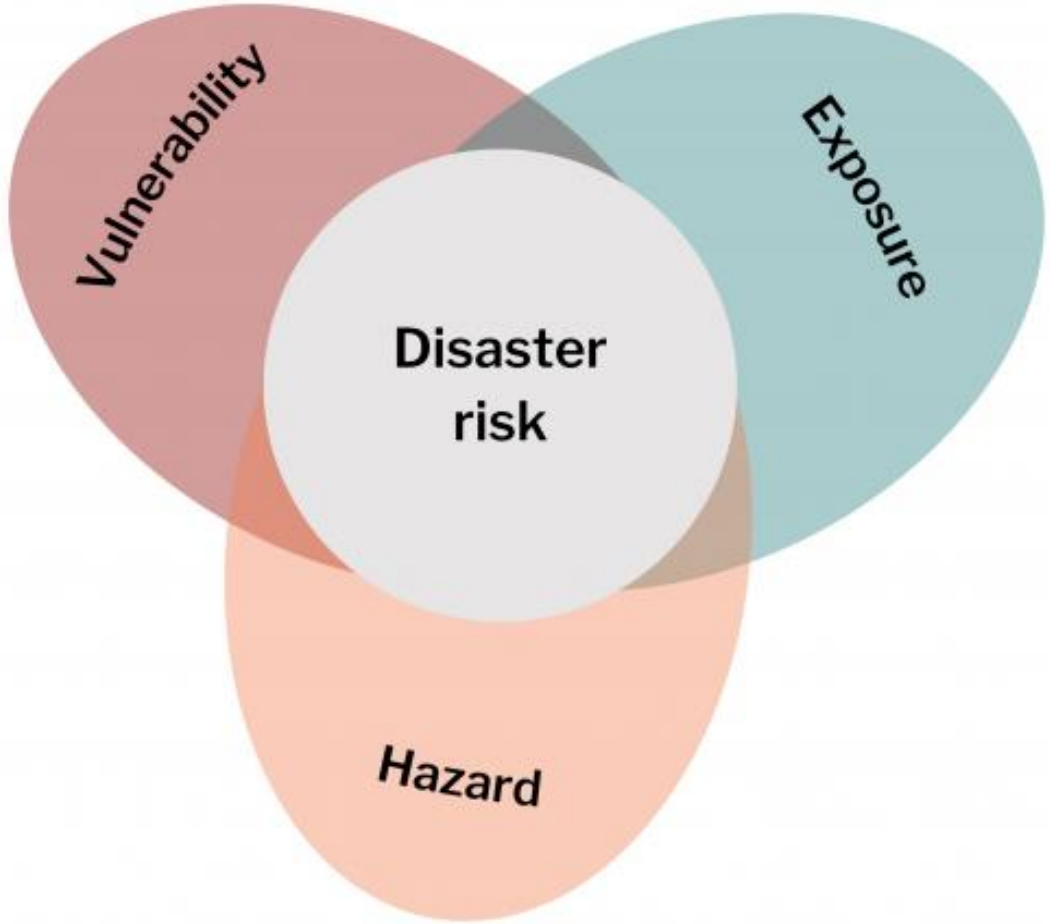
- Using one evaluation metric by combining agreement, overprediction (false positive), & underprediction (false negative).
- Wing et al., 2017 propose using a Critical Success Index in the article Validation of a 30 m resolution flood hazard model of the United States.
- Critical Success Index (CSI) accounts for both overprediction and underprediction.
- Range between 0 and 1, with 1 being a perfect match between the model and high-resolution engineered map.

$$CSI = \frac{Agreement}{Agreement + False\ Positive + False\ Negative}$$

Risk Analysis: Hazard, Exposure, Vulnerability, Consequence

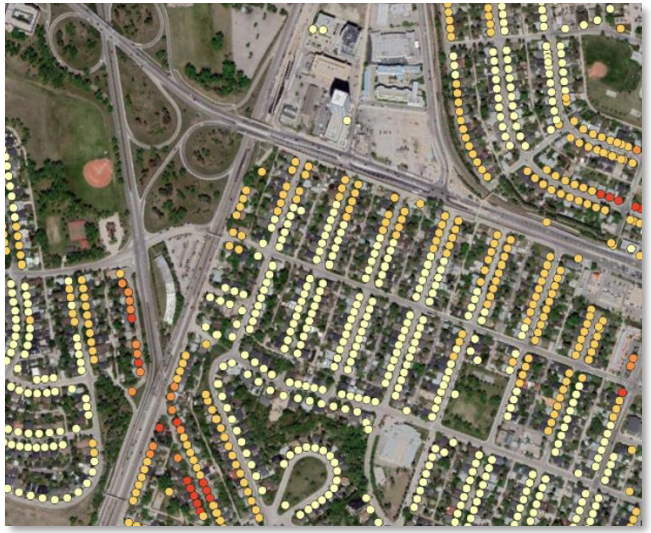
- Risk is a combination of:
  - **Hazard**: where the flood water is going and with what frequency
  - **Exposure**: what we value that is contacted by the flood water
  - **Vulnerability**: the characteristics of what we value that make it susceptible to impacts
  - **Consequence**: the impacts that occur when flooding contacts things we value

- For estimating Financial Risk, a useful metric is ‘Average Annual Loss’:
  - This metric presents a dollar value of flood damage annualized over a long time horizon, capturing small floods, large floods, and years with no flooding.



Exposure: Developing a Residential Exposure Data

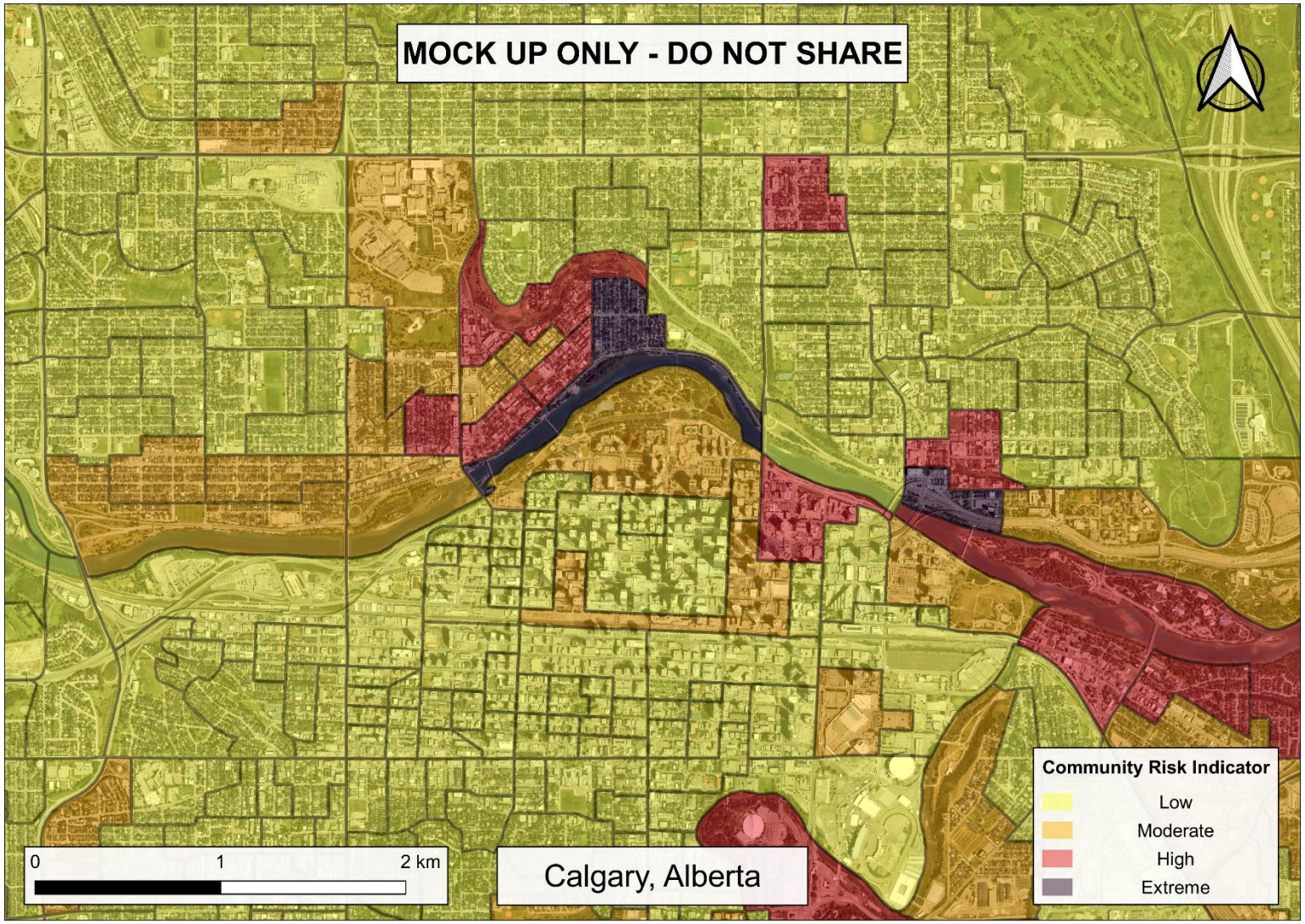
- A combined exposure data set of residential addresses was generated, and filtering and quality control algorithms were used to improve data set accuracy:
  - DMTI Address Point Data
  - Microsoft Building Location Data
  - StatsCan Building Location Data
  - Open Street Maps Building Data
  - Opta building attribute data



- Processing this data to develop a consolidated exposure data set was a large undertaking, and involved a considerable quality control effort

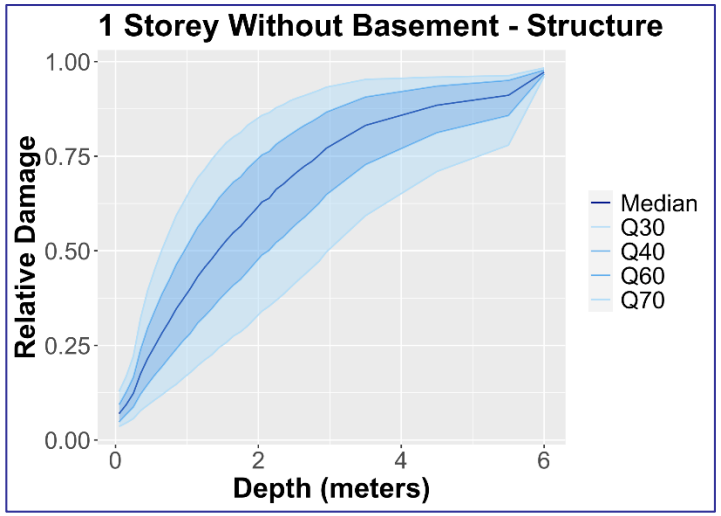
Vulnerability Assessment

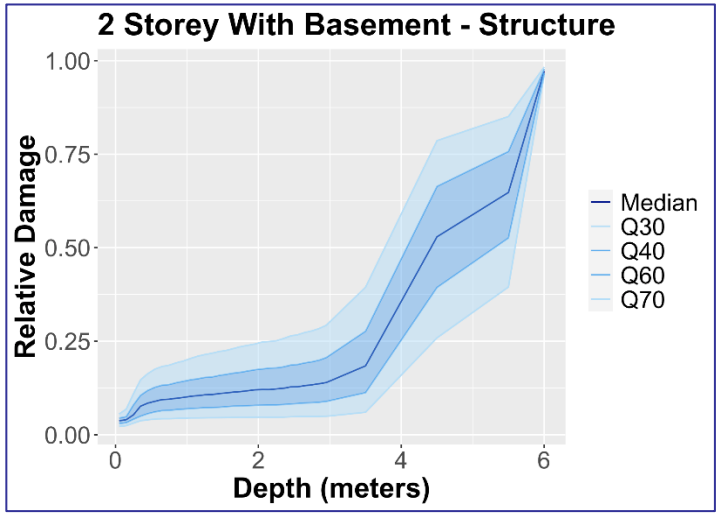
- Public Safety Canada has conducted Social Vulnerability assessments in support of federal programs
- Vulnerability, including the Social Vulnerability Index (SoVI), provides a meaningful lens different from purely financial risk analyses
- Currently, SoVI initiatives at PS, NRCan, and Statcan are being combined into one comprehensive product



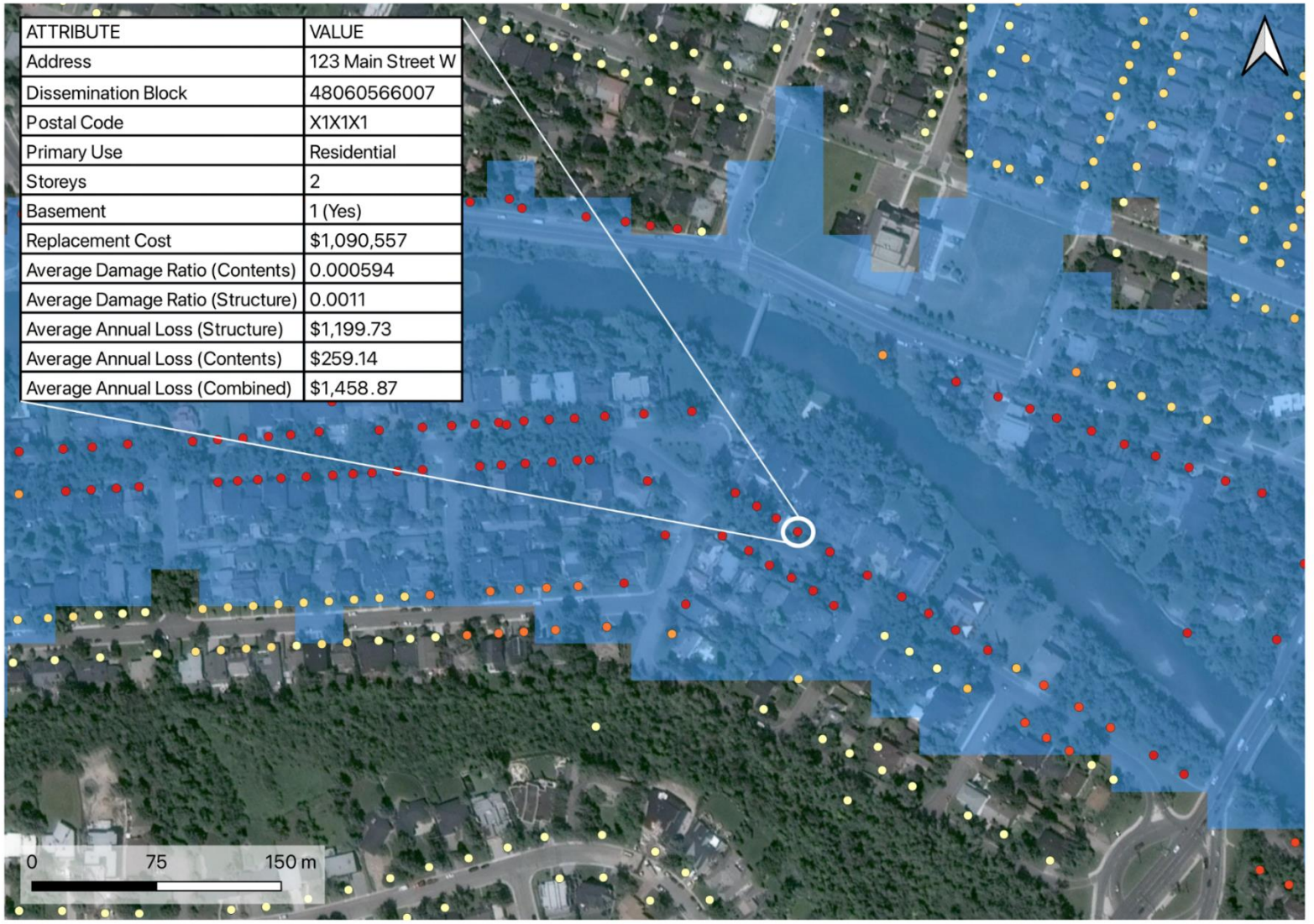
Damage Estimation Models

- Three flood damage estimation models were also procured from the data vendors:
  - JBA: Average Damage Ratio data (%) at a variable resolution grid
  - KatRisk: full catastrophe model (SpatialKat) with capability to process the entire exposure data set
  - Aon: Average Annual Loss data (%) at the dissemination block level
- In addition, a series of depth-damage models were procured from Fathom in order to develop three additional estimates using each vendor's flood hazard data.



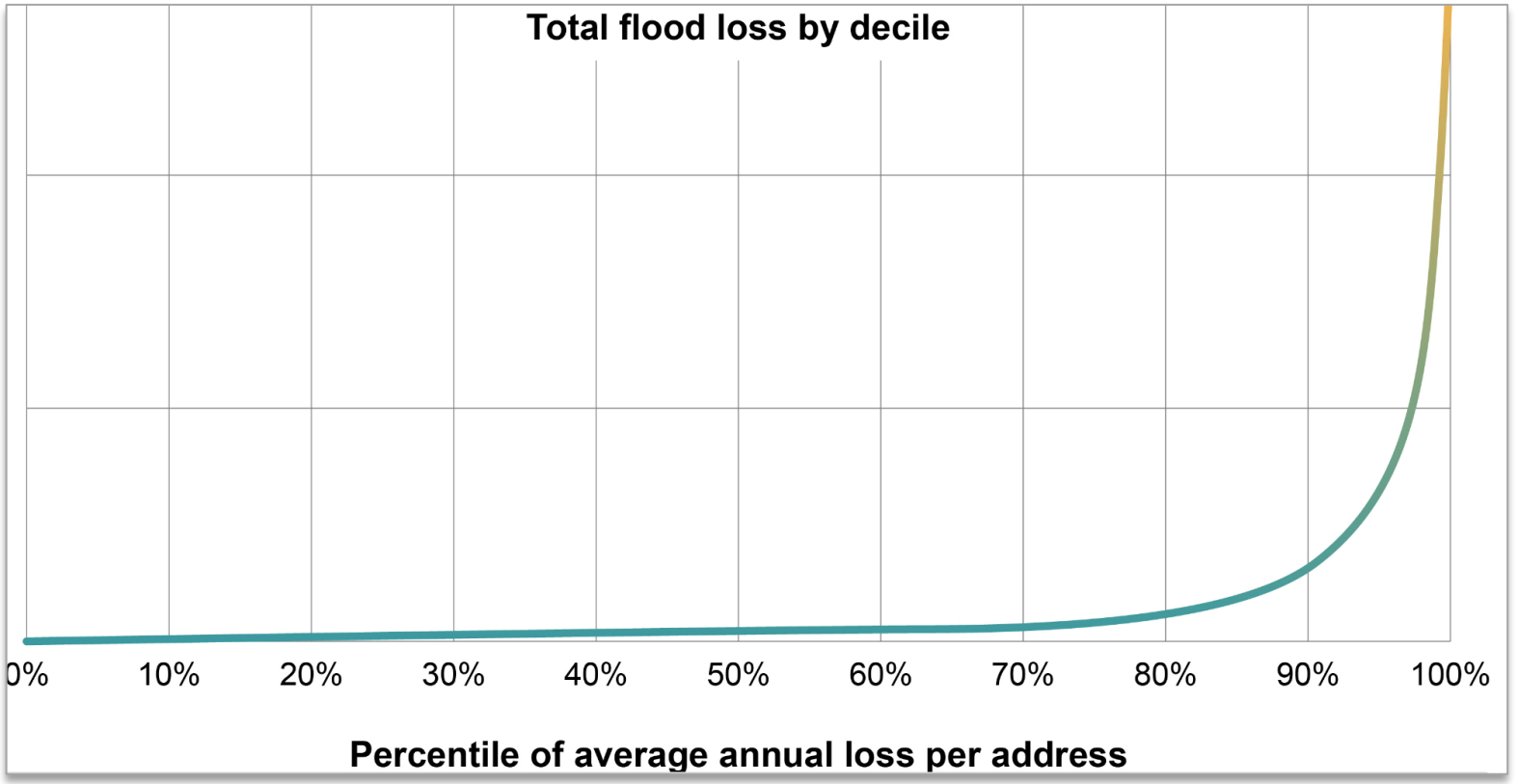


Damage Estimation



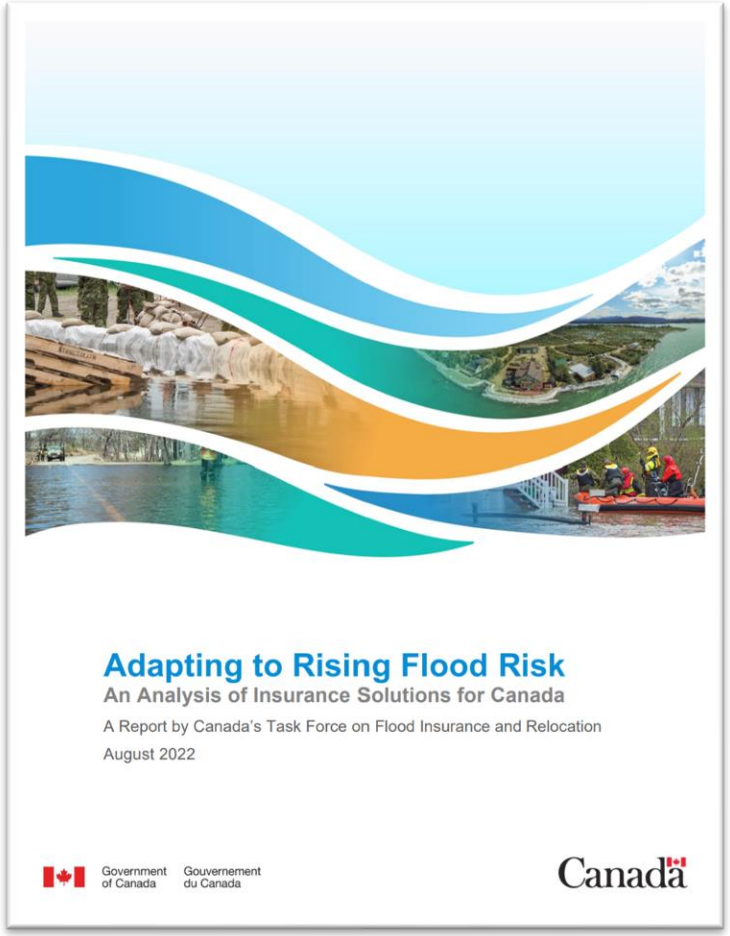
Financial Risk Analysis for Canadian Households

- The top 10% of riskiest residences account for roughly 90% of the total AAL.
- The top 1% of riskiest residences account for roughly 34% of the total AAL.



Financial Flood Risk Assessment: Insurance

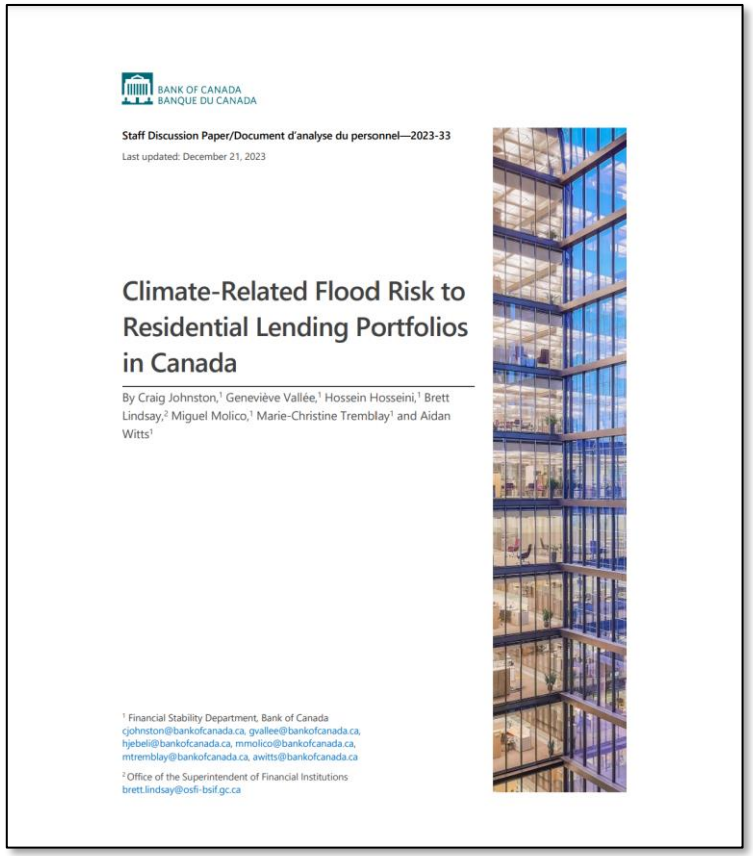
- Estimated Average Annual Loss (AAL) for all residential addresses in Canada and provided loss estimates to an actuarial team to conduct analysis of insurance options.
- See report titled: ***Adapting to Rising Flood Risk: An Analysis of Insurance Solutions for Canada*** published August 2022.



Financial Flood Risk Assessment: Bank of Canada

- Estimated Average Annual Loss (AAL) for all residential addresses in Canada under different climate change scenarios to estimate future losses in the residential housing market
- See report titled: ***Climate-Related Flood Risk to Residential Lending Portfolios in Canada***

  [staff discussion paper 2023-33]



BANK OF CANADA
BANQUE DU CANADA

Staff Discussion Paper/Document d'analyse du personnel—2023-33

Last updated: December 21, 2023

Climate-Related Flood Risk to Residential Lending Portfolios in Canada

By Craig Johnston,[1] Geneviève Vallée,[1] Hossein Hosseini,[1] Brett Lindsay,[2] Miguel Molico,[1] Marie-Christine Tremblay[1] and Aidan Witts[1]

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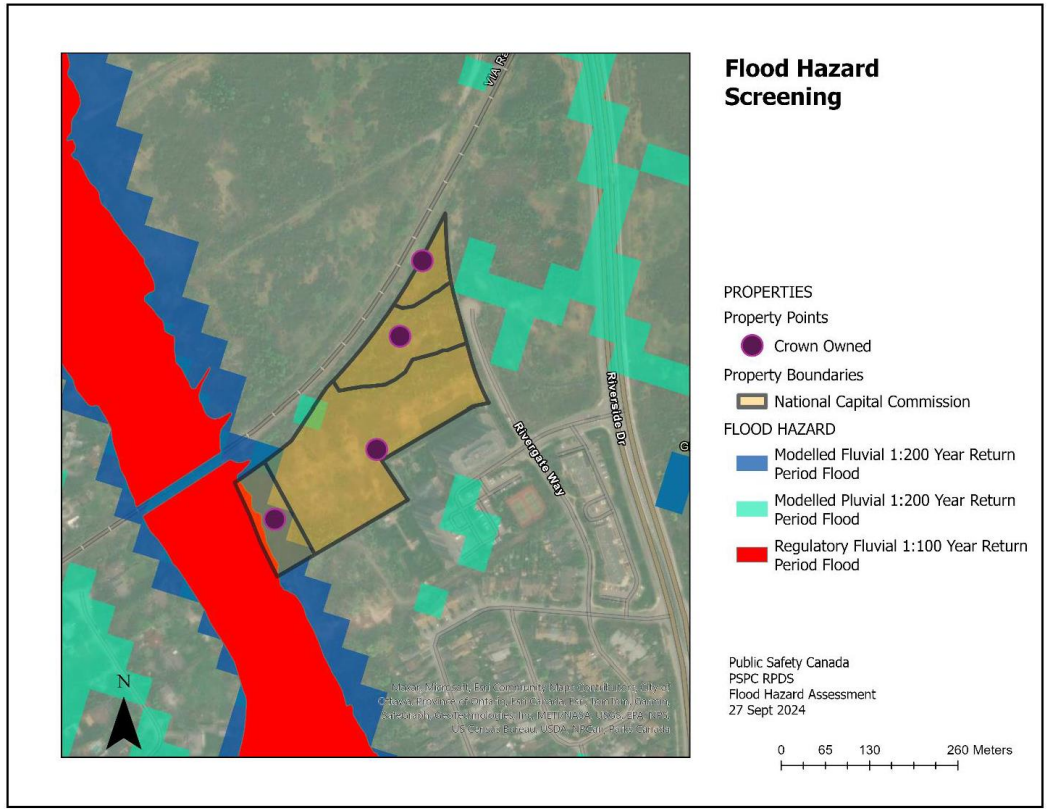
Flood Hazard Assessment: PSPC

- Flood Hazard Screening for Canada Lands properties using Regulatory Mapping and Flood Hazard Modelling
- Provides an assessment of flood hazard estimation from two different methodologies for all of Canada



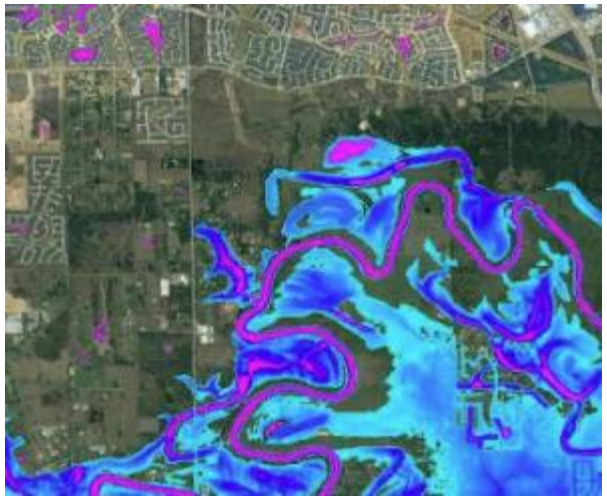
Federally Identified Flood Risk Areas (FIFRA) Program

Canada-wide Flood Hazard Model – QAQC

Methodology Research

Matrix Approach

Data Analyses



Low	Moderate
High	Extreme

FIFRA Communication - Flood Risk Awareness Digital Resource

- The Flood Risk Awareness Digital Resource will provide **centralized flood hazard information** to help individuals and communities be better informed and prepared for flooding.
- In addition to publicly communicating the FIFRA, the Resource will also include knowledge, guidance, tools and resources to make informed decisions about flood risk.
- The Resource will link to **Canada's Flood Mapping Inventory** to identify areas in Canada where a flood hazard map has been collected by NRCan.

Your Flood Risk is **MODERATE**

This property is in an "X Zone" according to the Federal Emergency Management Agency's flood insurance rate map. It is located in a low-lying area in a rainy climate and is protected by a levee.

There are other things you can do to lower your risk:

- Clean in front of your catch basins - $
- Elevate your utilities - $
- Install green infrastructure - $ - $$
- Elevate your home - $$$

Source: https://ready.nola.gov/rain/

The above images are used for example purposes only.

Summary of Current Initiatives

- Disaster Financial Assistance Arrangements Program Modernization
- Flood Insurance Program for Canada
- Community Risk Index (CRI) development:
  - Combination of residential loss (AAL), Social Vulnerability, and Community Resilience into an index aggregated at the Dissemination Area level
- Multihazard work including partnerships in wildfire and seismic risk
- Coordinated Exposure Data Network (CEDN)
- Disaster Risk Reduction (DRR) Data Strategy, partner with StatCan
- Other collaborations and natural hazard risk assessment as a service for other departments and organizations such as CMHC, Bank of Canada, PSPC, etc.
- Funding for National Science and Engineering Research Council (NSERC) flood hazard research

Questions?

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