MAPPING METHODOLOGY
Introduction/context

Not yet any national mapping standards

Provincial/municipal maps:
- Have variable coverage
- Are often outdated
- Are provided in inconsistent formats

Ambitious project – mapping for every single river, plus pluvial flooding

Considering data availability, what could we achieve?
Mapping approach

Traditional engineering approaches to flood mapping, but with a hi-tech twist!

Extensive validation and correction at all stages

- **Generate river network and catchment boundaries**
  - GIS analysis of elevation data
  - Correction of any errors

- **Hydrological modelling**
  - Generate river flow estimates and rainfall totals
  - Different methods to reflect different river regimes

- **Hydraulic modelling**
  - Largest dedicated flood modelling grid in the world
  - Different methods to suit different elevation data
Elevation data

Digital Surface Model (DSM)
- represents the earth’s surface as detected by radar
- includes features such as tree canopies and tall buildings

Digital Terrain Model (DTM)
- representation of the true ‘bare-earth’ ground level

34% of national population mapped on bare-earth terrain data
Hydrology introduction

Purpose: methods to calculate river flows and rainfall totals for any ungauged location in the country

No published Canada-wide methods for estimating these

However, high quality data plentiful
Hydrology overview

Input data

- Water Survey of Canada - HYDAT database of 1,664 river gauge records
- Environment Canada – IDF curves and snow depth records at 565 gauges
- Ecological Framework of Canada – ecozones to calculate losses e.g. from urban drainage

Represents local characteristics

- Significant influence of lakes
- Snow-melt
- Frozen impermeable ground

Environment Canada rain gauges

Rainfall surface - 20yr - 1hr duration
High : 55 mm
Low : 5 mm

20yr rainfall surface – 1 hr duration

55mm
5mm
Design rainfall estimation

Rainfall hyetographs for every catchment across Canada

Intensity-duration-frequency (IDF) statistics at 565 gauges used to calculate rain depth per return period

Three storm durations for each return period, to capture critical storm duration in different topographies

Adjusted to account for snowmelt & frozen ground

Interpolated to create continuous rainfall surfaces

Hyetograph generation using US Soil Conservation Service method

Percentage runoff varies with land use
Snowmelt & frozen ground

Rain on snow can lead to significant flooding

Losses reduced by:
- Priming of depressions (snow-filled)
- Frozen ground
- Lack of vegetation

Volume of water from snowmelt on successive days calculated from snow depth gauges

Snowmelt amounts combined with rainfall totals to generate winter runoff at each gauge

Considered alongside summer rainfall totals – worst case taken forward
Peak flow estimation for main rivers

Input data (HYDAT flow data, lakes, catchment boundaries)

Calculation of an index of lake attenuation

Estimation of the index flood (QMED) at suitable gauging stations

Calculation of an index of lake attenuation

Data checking & development of flood peak dataset – daily mean and instantaneous AMAX flows

Development of regression model to estimate QMED from effective catchment area and FARL

Calculation of QMED for ungauged catchments

Calculation of QMED for ungauged catchments

Flood Frequency Analysis - fitting of growth curves (GEV distribution) at gauged locations

Regionalization: spatial interpolation of L-moment ratios using kriging

Calculation of return period design flows at ungauged locations using growth ratios and QMED

Adapted from Faulkner, D., Warren, S. and Burn, D (2015) – Design floods for all of Canada. Accepted by Canadian Journal of Water Resources
Hydrology summary

We developed methods that enabled us to:

- Calculate rainfall amounts for all catchments in Canada
- Calculate river flows for 24,000 locations along the national river network
- Account for the impacts of snowmelt
- Represent different land uses and ground conditions

These form some of the inputs into our hydraulic models…
Hydraulic modelling

RFlow®
- Extremely fast
- Credible outputs
- Used in largely unpopulated areas

JFlow®
- Fast
- Specifically designed for large-scale hazard mapping
- Developed since 2002
- Benchmarked by UK government
What’s the result?

National flood hazard maps for 7 return periods at 30m resolution

> 5 million km of river mapped

Pluvial flooding for every location

Full 2D hydrodynamic simulations for three storm durations, for each return period, on a 30m grid!
River Flood - Calgary
Application of flood hazard maps

Insurance metrics

- Underwriting/risk scores
- Pricing tools
- Eg Annual Damage Ratios

Probabilistic models

Flood warning & forecasting systems

LOCATION A
Total insured value of building = C$300,000
MeanADR Buildings = 0.00012
Buildings flood premium = $36

LOCATION B
Total insured value of building = C$300,000
MeanADR Buildings = 0.000008
Buildings flood premium = $2.40

LOCATION C
Total insured value of building = C$300,000
MeanADR Buildings = 0.00266
Buildings flood premium = $798
What’s next?

Understanding of flood risk across Canada is better than ever – but more to do!

- Local hydrology & hydraulic studies

To do more, we need more:

- Flood defence data
- High quality terrain data – LIDAR
- Investment

We are here!
Thank you!

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Flickr user Ryan McGilchrist. Taken April 21st 2013. Highway 11. Attribution License 2.0
Thank you!

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Q&A