1 in 250 years flood plain map for Calgary (source: Impact Forecasting)

Residential Flood Insurance in Canada and Learnings for the US

Model developer's point of view

… aka why was the Canadian flood model built by a team of Czechs?

Prepared by Adam Podlaha of Impact Forecasting

Presentation for the CAS 2017 RPM seminar

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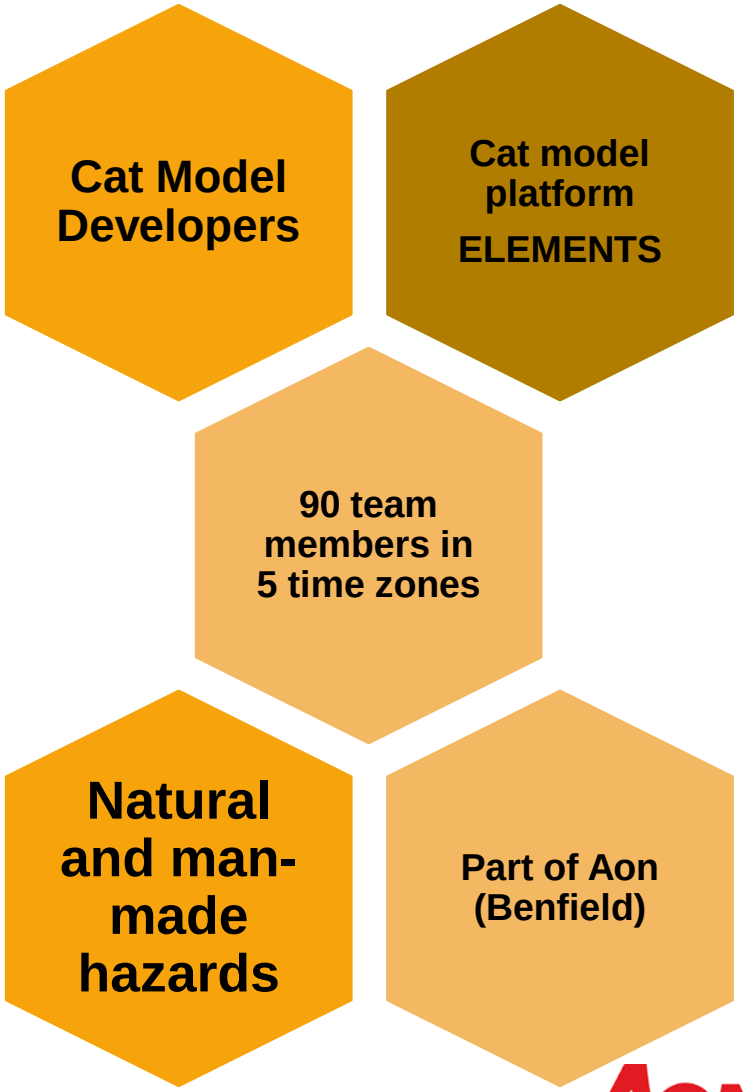
Agenda

Section 1	Who are we?
Section 2	What did we develop?
Section 3	Lessons learned
Section 4	Comparison with US and Europe
Section 5	What next?
Appendix	Flood map vs. probabilistic model

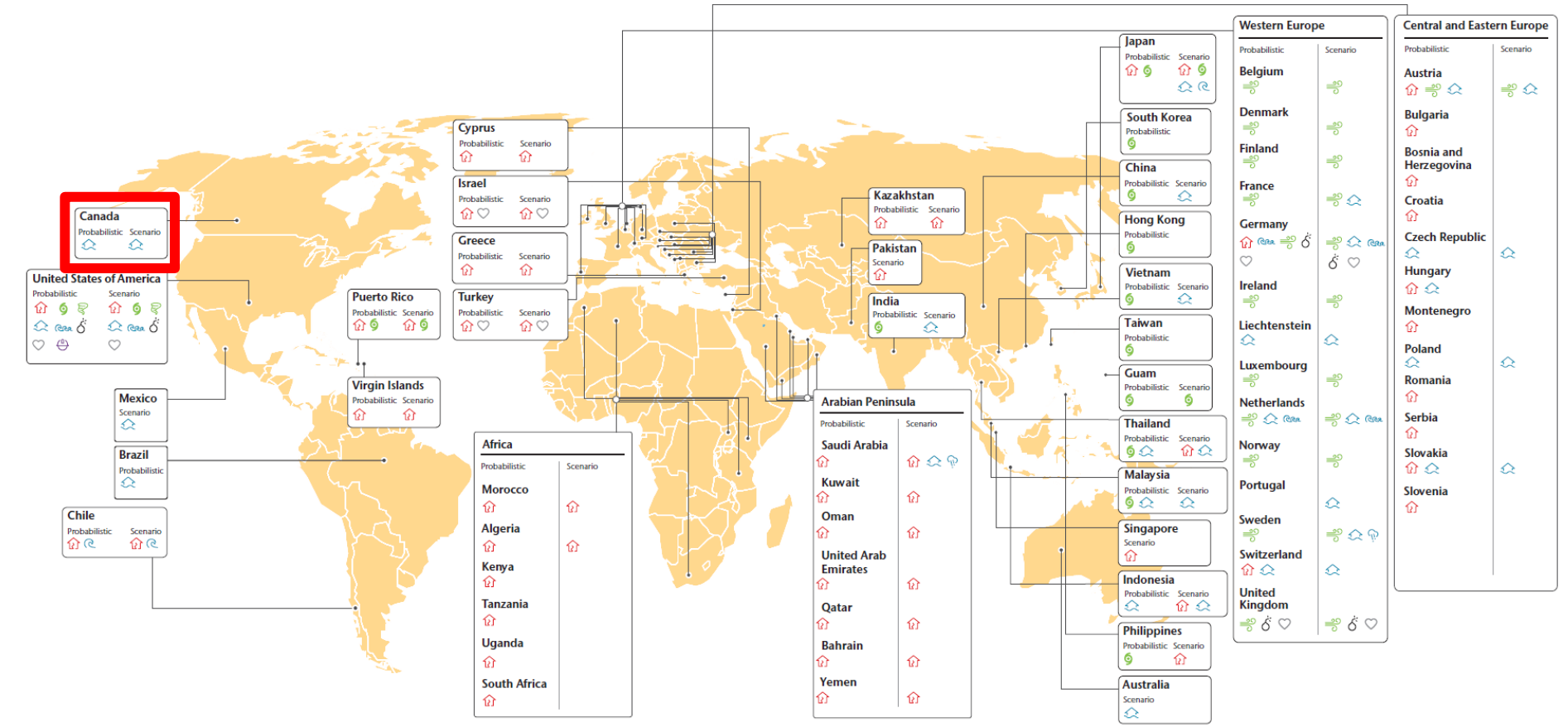
Section 1: Who are we?

Who are we?

- Catastrophe model development team fully owned by of Aon
- **Independent**, **transparent**, **open**, **modular** and **bespoke** models
- **Natural** (flood, earthquake, wind) and **man-made** perils
- Filling the gaps as well as main perils
- Products licensed to over 50 clients
- Canadian flood model since 2015 and still in development



More than 100 models in over 60 countries



Used by insurers, reinsurers and 3rd parties

- **15+** insurance companies (4 out of top 5)
- **4+** local and global reinsurers
- Partnerships established with Opta, Spatial Key and Pitney Bowes

- **Usage of our model**
  - 15+ licences for data
  - 6+ ELEMENTS licenses (out of that 2 large primaries) + 2 proposals

- **Committed to the Canadian market**
  - Pluvial (Q4 2016 and Q4 2017), tsunami (done) and storm surge
  - Additional tools available
  - 2015 and 2016 workshops
  - Bespoke projects and analyses

economical mutual insurance company – good to know	Signed
RSA	Signed
BCAA / CAA	Signed
Portage Mutual Insurance	Signed
Gore Mutual	Signed
Unica Insurance	Signed
Peace Hills Insurance	Signed
The Commonwell Mutual Insurance Group	Signed
L'Unique General Insurance	Signed
La Capitale Financial Group	Signed

Insurance companies

SCOR, TransRe, XL Catlin, Farm Mutual reinsurance plan Inc.

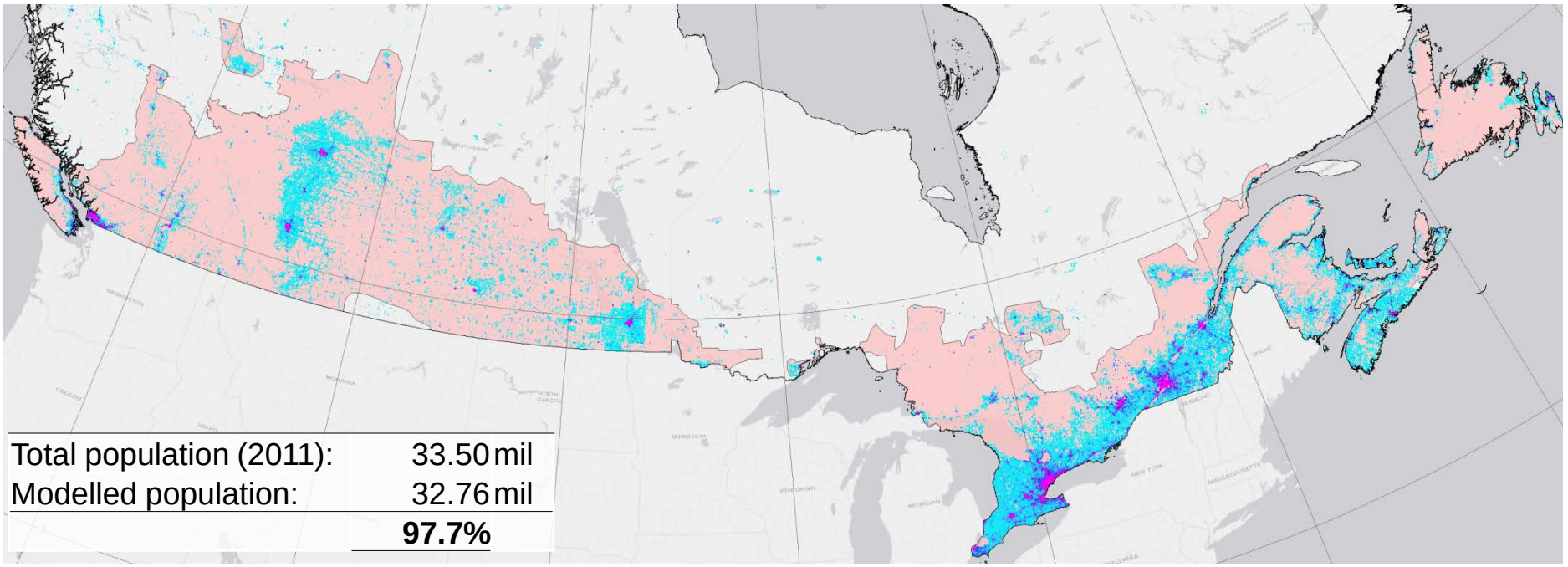
Reinsurance companies

opta information intelligence, SpatialKey, pitney bowes

Solution providers

Section 2: Our offering

Our model overview



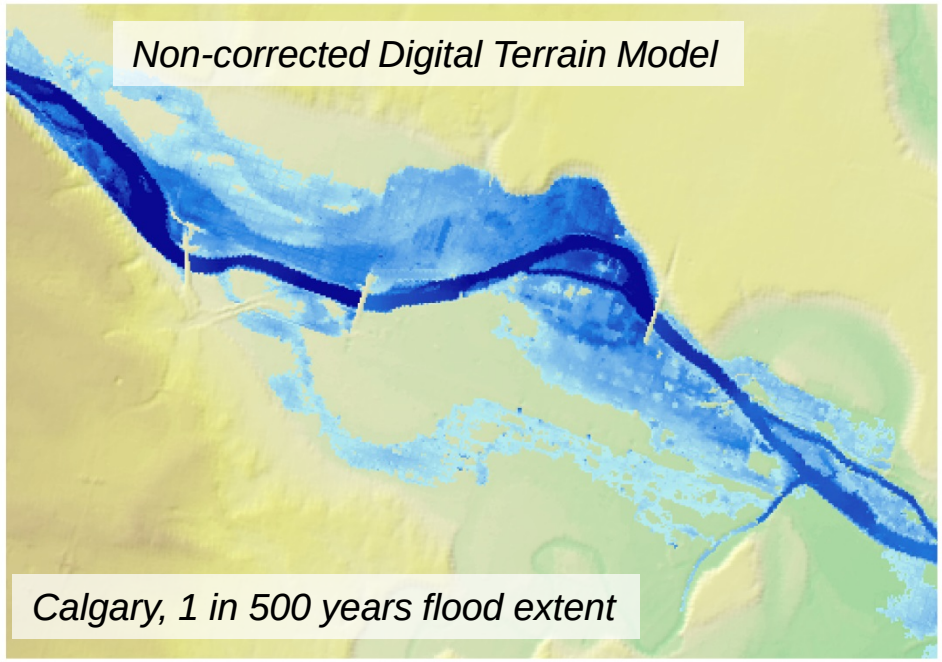
Total population (2011):	33.50 mil
Modelled population:	32.76 mil
	97.7%

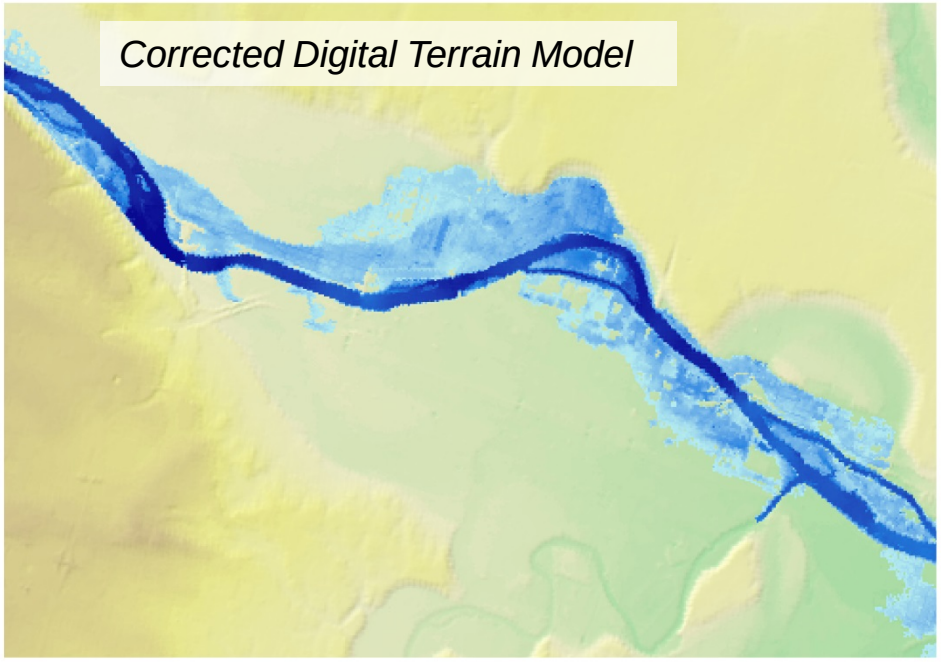
- Fully probabilistic physically based, covers **~98% of Canadian population**
- 2-dimensional hydrodynamic simulation used for **all modelled rivers**
- Supports **Lat & Lon; 6- and 3- digit postal codes**
- Vulnerability based on the **real Canadian flood claim** data (2013)

Working with elevation data is time consuming

…but well worth it

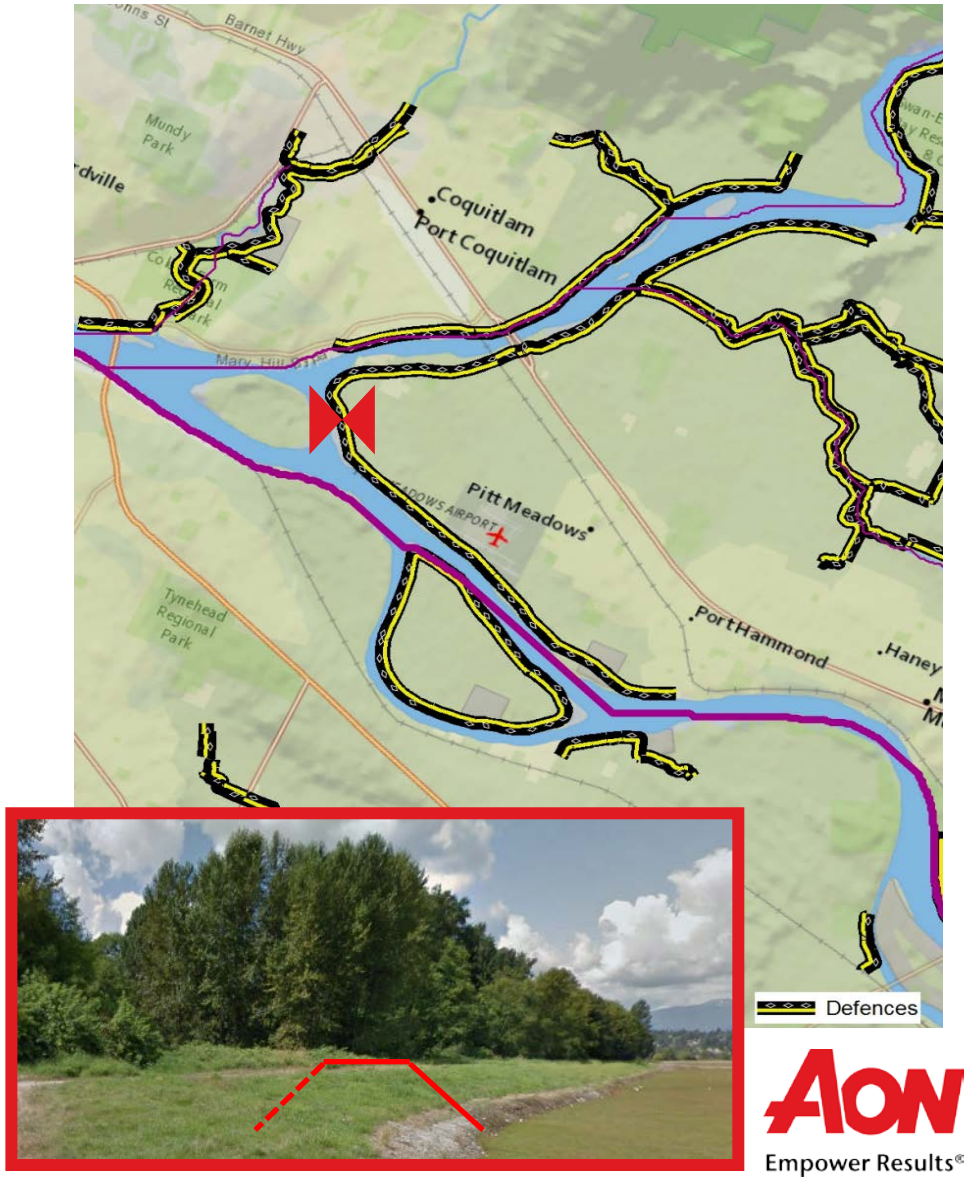
- Different **D**igital **T**errain **M**odels used
- Many manual DTM corrections were essential





Flood models are very data hungry!

- Geographical data
  - River network (GeoBase)
  - LandCover (Environment Canada)
  - Postal codes (GFK, Canada Post)
- Hydrological data
  - Daily discharges of 1,526 locally sourced stations
  - Cleaned & checked
  - Used for event set generation
- Flood defence data
  - Significant effect on losses
  - Extensive research in their location and standard of protection
  - Manually checked and corrected



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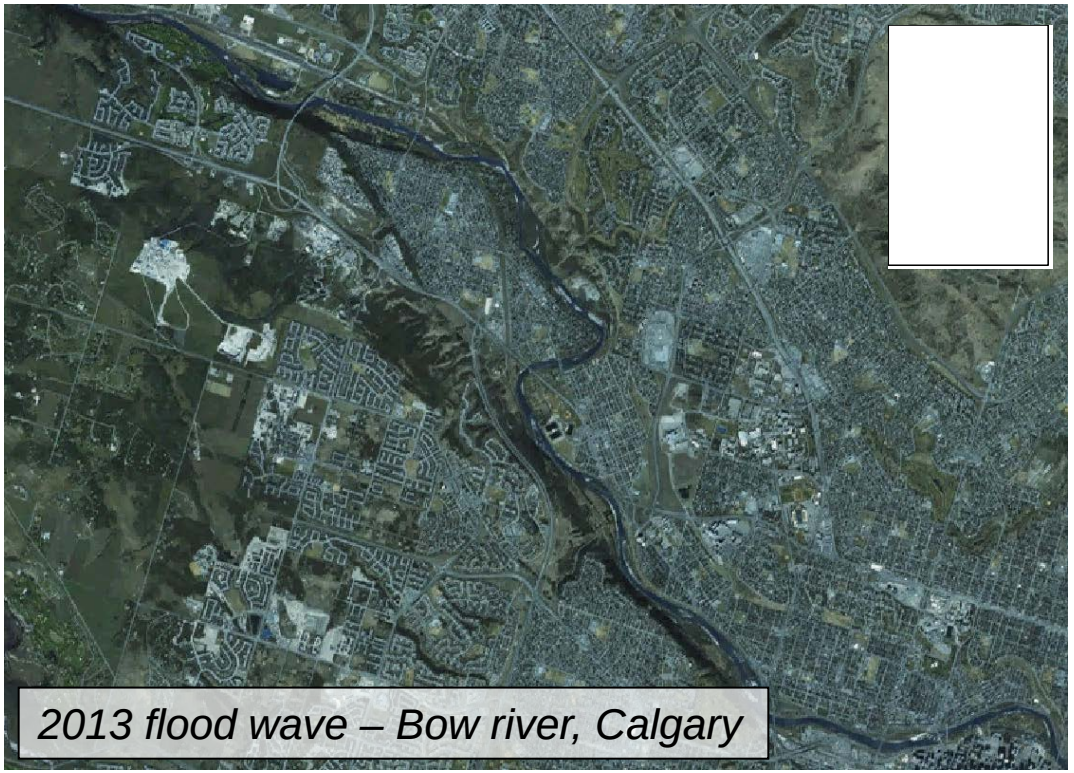
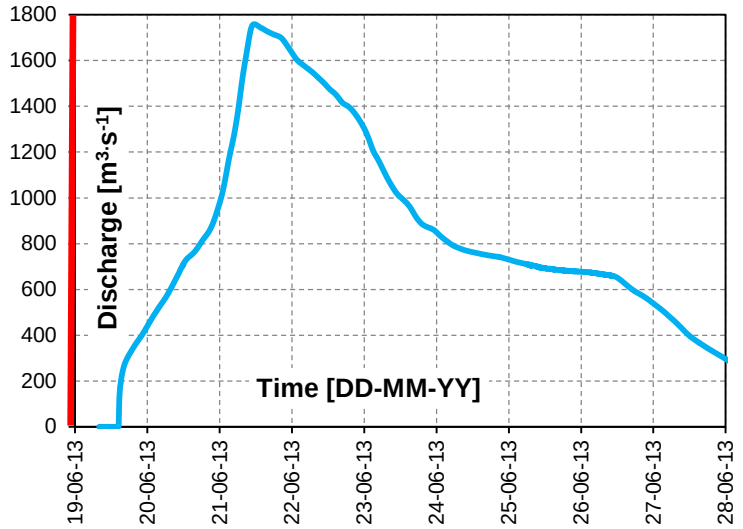
Physical based model

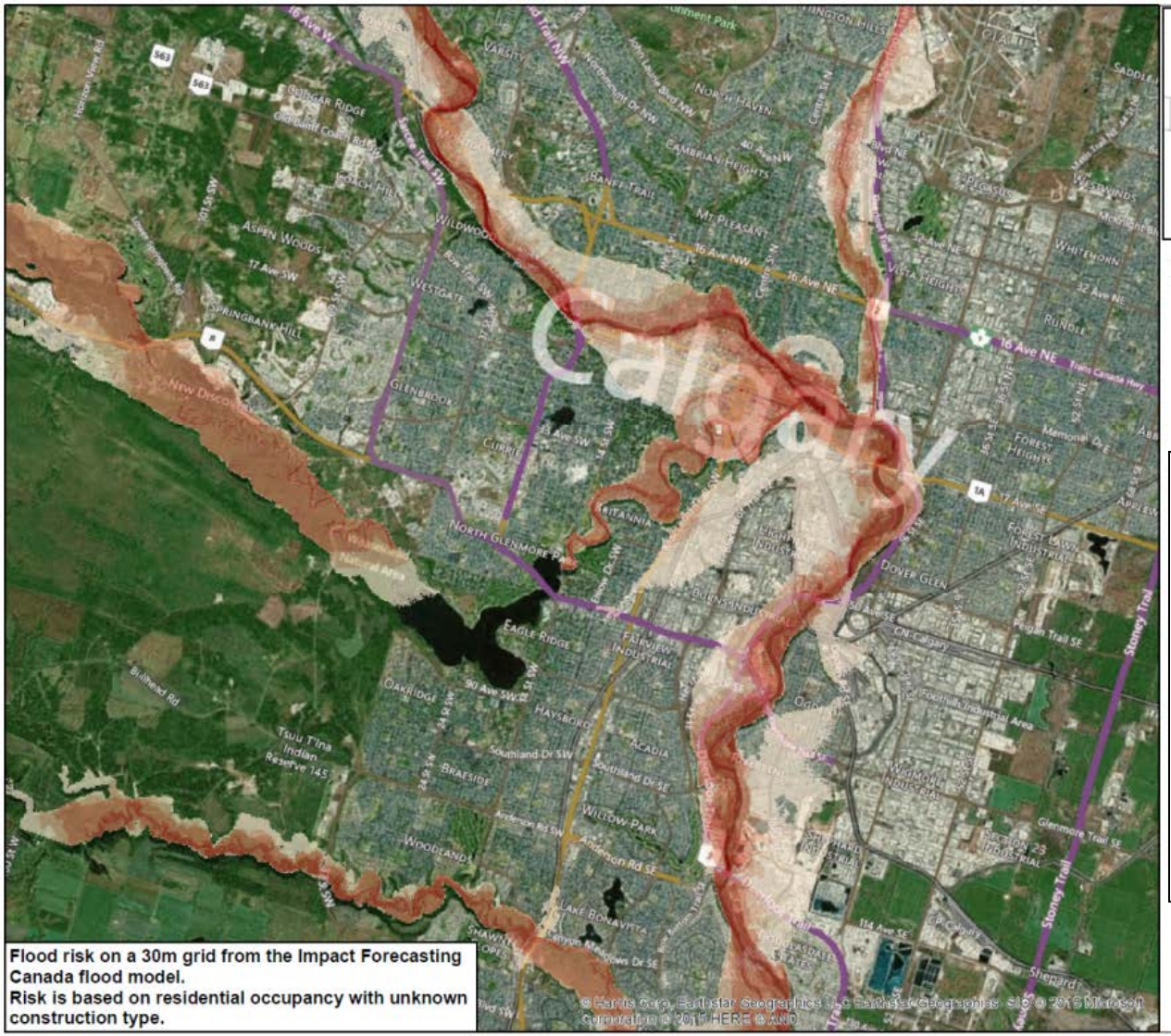
- **2D hydrodynamic model TUFLOW used for the entire modelled area**
  - Provides real (physical) flow of water
  - Computationally challenging: **835** days of runtime

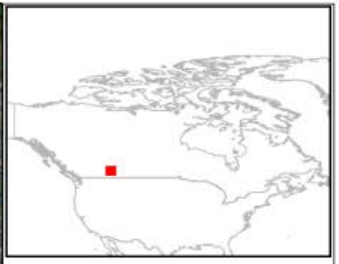




…so how can the model be used for pricing?

Our “flagship” detailed product (for the actuaries)





Residential Grid Cell Flood Risk

N

Pure Premium (AAL)
(as % of TSI per Zone)

- < 0.04
- 0.05 - 0.1
- 0.11 - 0.2
- 0.21 - 0.4
- > 0.41

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Our “flagship” detailed product (for the actuaries)

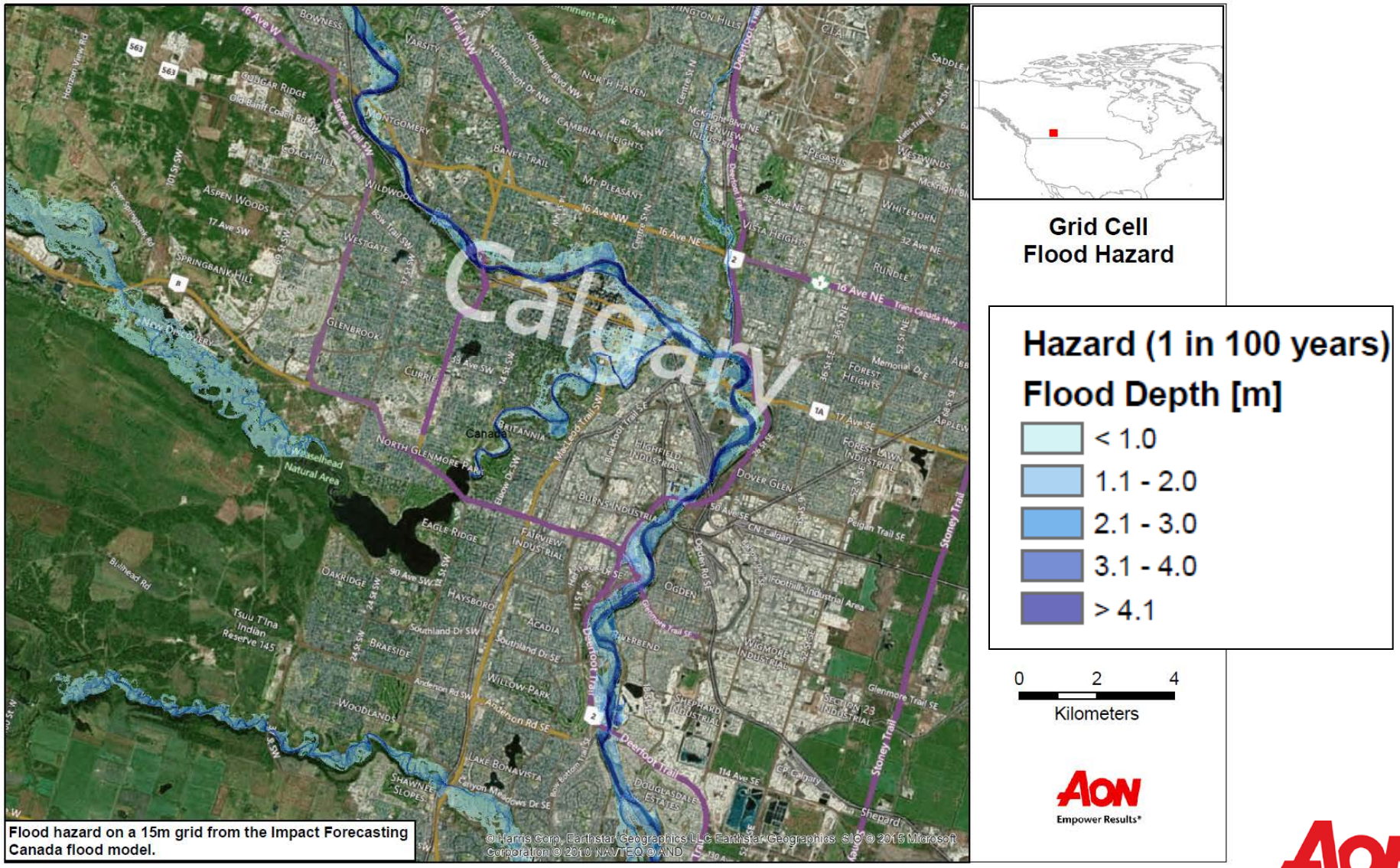
6-digit postal code

Postal code	Pure Premium
T0J0V0	0.0053%
T0L0X0	0.0016%
T0L1W0	0.0069%
T0M1L0	0.0015%
T0M0S0	0.0019%
T4B2M1	0.0011%
T4B2V1	0.1296%
T4B2Y1	0.1651%
T4B3B5	0.0014%
T4B3G5	0.0423%
T4B3G6	0.0963%
T4B3G7	0.1278%
T4B3K8	0.0006%
T4B3K9	0.0070%
T4B3L1	0.0393%
T4B3L2	0.0302%
T2Y3T9	0.0928%

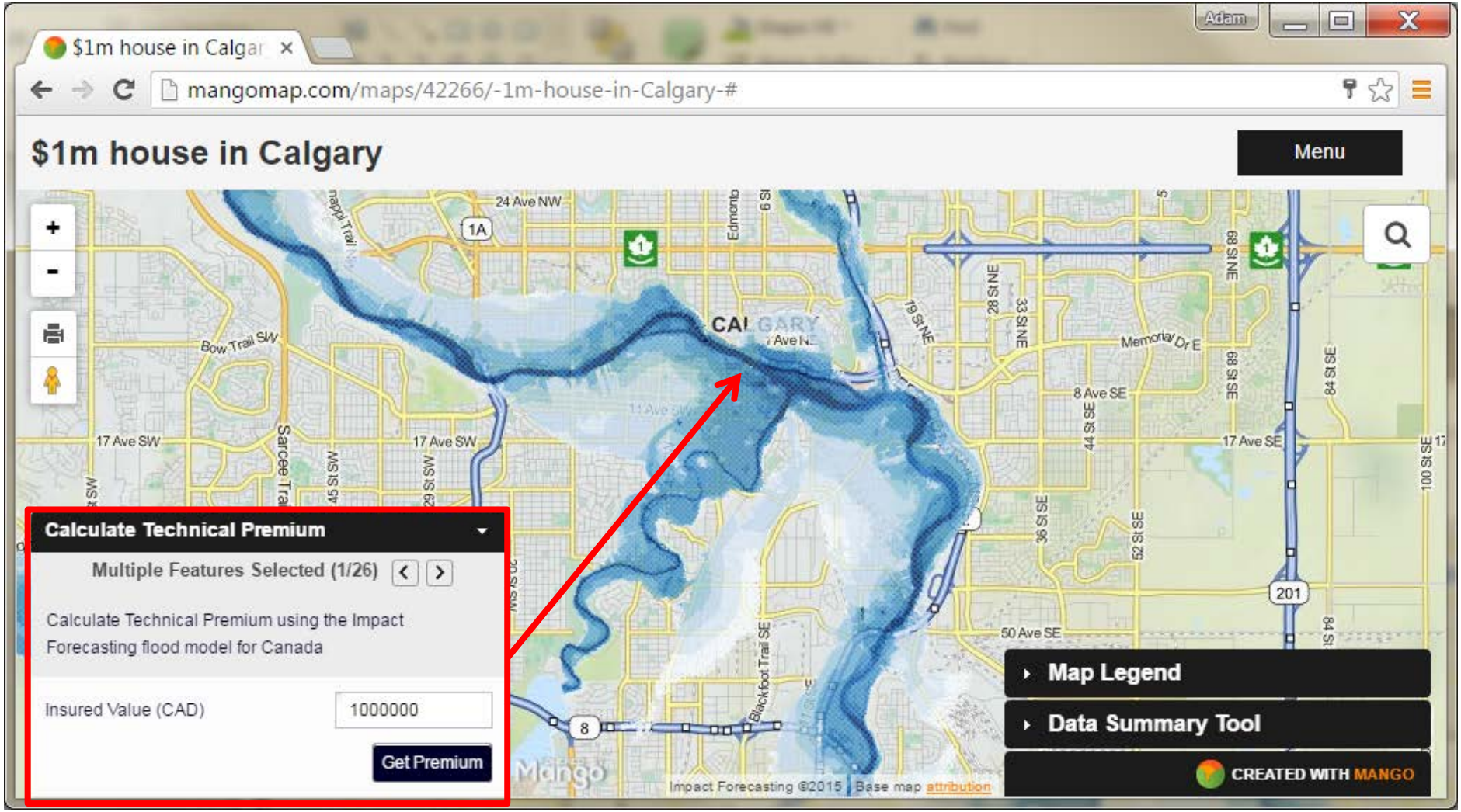
30 x 30m

Latitude	Longitude	Pure Premium
50.8784	-113.9893	0.0269%
51.0017	-114.1802	0.1893%
51.2532	-114.0001	0.0965%
51.0139	-114.2182	0.1941%
51.0797	-114.1798	0.0166%
51.0123	-114.0632	0.0569%
51.0989	-114.2458	0.2421%
50.9742	-114.0301	0.2081%
50.9311	-114.1922	0.1222%
50.9758	-114.0084	0.0000%
51.0034	-114.1990	0.1673%
51.0019	-114.2137	0.1496%
50.9298	-113.9923	0.2061%
51.3213	-114.0235	0.0636%
51.0365	-114.0616	0.1790%
51.0907	-114.1907	0.0003%
51.0056	-114.2109	0.1833%

Why is a probabilistic model better than a flood map?

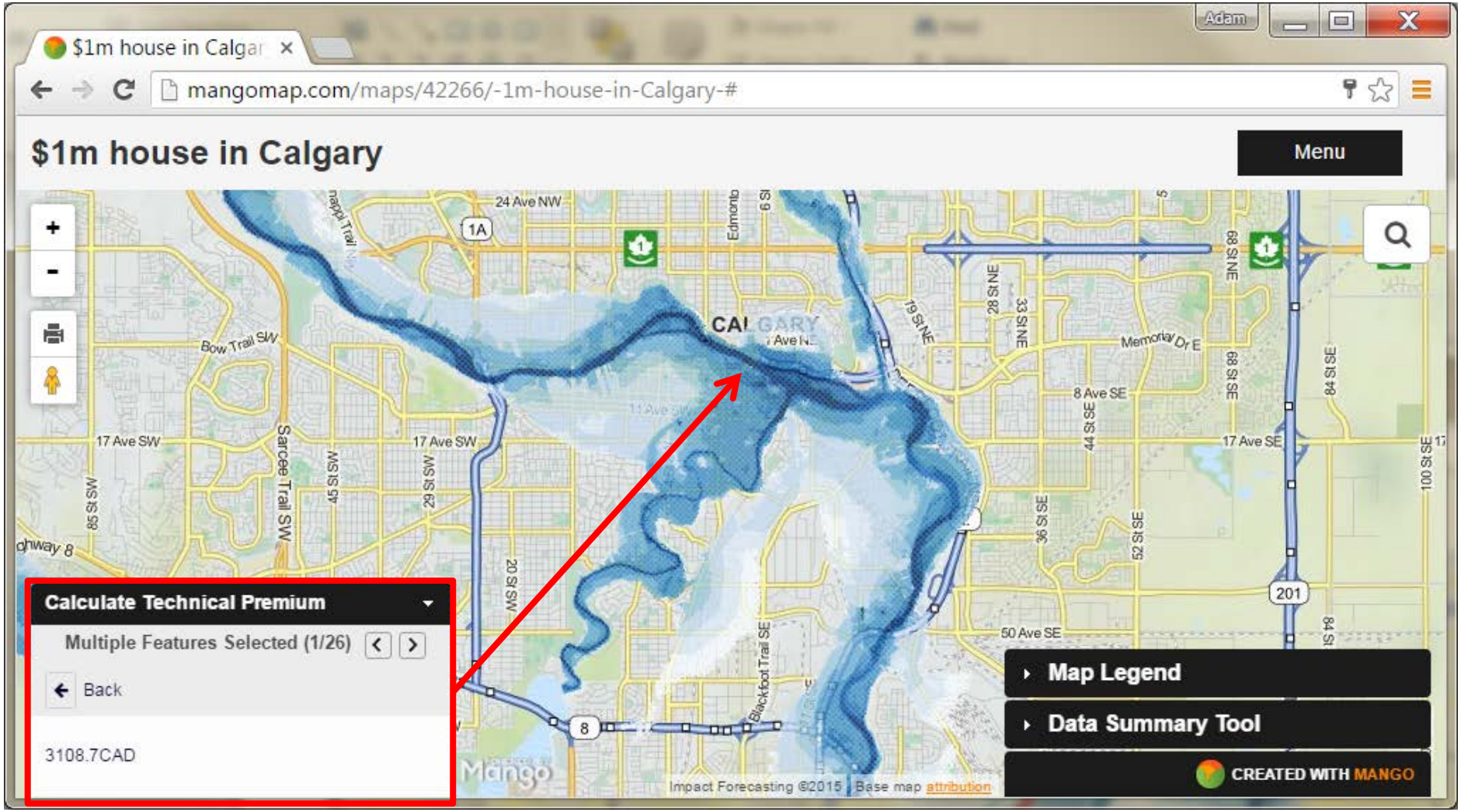


Demo implementation



Empower Results®

Demo implementation



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Sample results

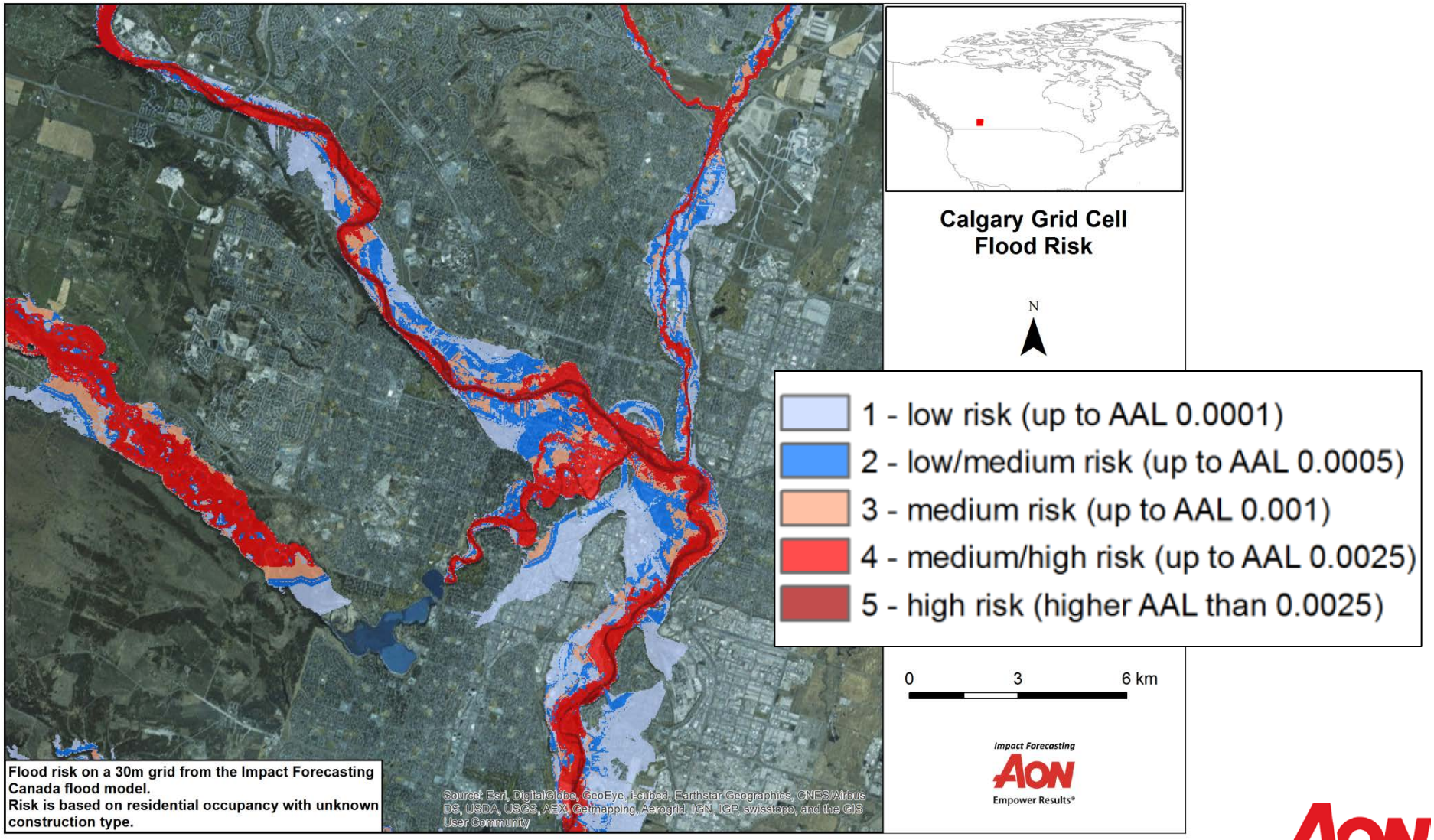
- Top 10, AAL and PMLs, **Use: rate calculation (basic)**

SiteNumber	PostalCode	Precision	TIV	GR_LOSSRP_100	GR_LOSS_AAL	GU_LOSSRP_100	GU_LOSS_AAL
711		PostalCode	127,528,682	4,111,506	293,222	4,115,918	293,563
1234		Coordinates	16,699,158	486,201	54,291	535,395	59,238
10868		Coordinates	6,062,284	1,889,337	43,175	2,068,970	48,054
7690		Coordinates	50,767,032	4,804	38,229	145,009	66,138
3071		Coordinates	20,617,011	132,083	35,452	132,084	35,879
1662		Coordinates	21,128,948	1,395,575	32,833	1,448,495	34,315
10051		Coordinates	17,438,828	2,133,889	29,399	2,445,418	34,908
7091		Coordinates	1,856,474	493,357	25,697	550,050	29,608
712		PostalCode	32,713,196	307,934	24,830	311,946	25,120
6892		Coordinates	11,084,001	1,596,345	22,340	1,645,467	23,185
8919		Coordinates	5,979,363	1,149,682	21,662	1,253,433	23,864
3397		Coordinates	6,350,209	162,509	20,883	198,904	25,385
8802		Coordinates	7,431,668	916,846	19,897	1,009,079	21,980
10174		Coordinates	18,159,715	358,246	18,057	528,765	27,159
2405		Coordinates	16,477,444	8,368	17,329	91,023	32,065
7533		Coordinates	4,953,009	647	17,270	33,261	21,661
9476		Coordinates	14,647,815	144,536	15,284	144,536	15,284
6978		Coordinates	16,525,937	243,174	14,851	249,351	15,245
11167		PostalCode	24,266,649	35,665	14,375	99,301	21,585
4946		Coordinates	8,241,706	35,347	12,765	51,995	14,411

1 in 100y AAL 1 in 100y AAL

Calgary, AB T2S 2T4, Canada

And our simplified product (for the underwriters)



Section 3: Lessons learned

Lessons learned working with the Canadian insurers

For model developers

- **Lesson 1:** Make sure you have the right people at the meeting: 1. product, 2. risk manager and 3. pricing actuary. Reinsurance broker is optional

- **Lesson 2:** Make sure that you explain properly the difference between an actuarial model and a catastrophe model (loss data vs. “real” modelling)

- **Lesson 3:** Run some real sample data of that particular company through the model to illustrate how the model can be used

- **Lesson 4:** Be super conservative in terms of how long do your clients need to design the new flood product. Think 3rd parties

- **Lesson 5:** Be both receptive and critical to new ideas and requests from your client as some of them can be very innovative

Lessons learned working with the Canadian insurers

For pricing actuaries and product developers

- **Lesson 1:** Cat modelling is like black magic, ask as many questions as you can, don't get discouraged by unknown words. Ask about distributions!

- **Lesson 2:** Make sure that you understand properly the difference between an actuarial model and a catastrophe model

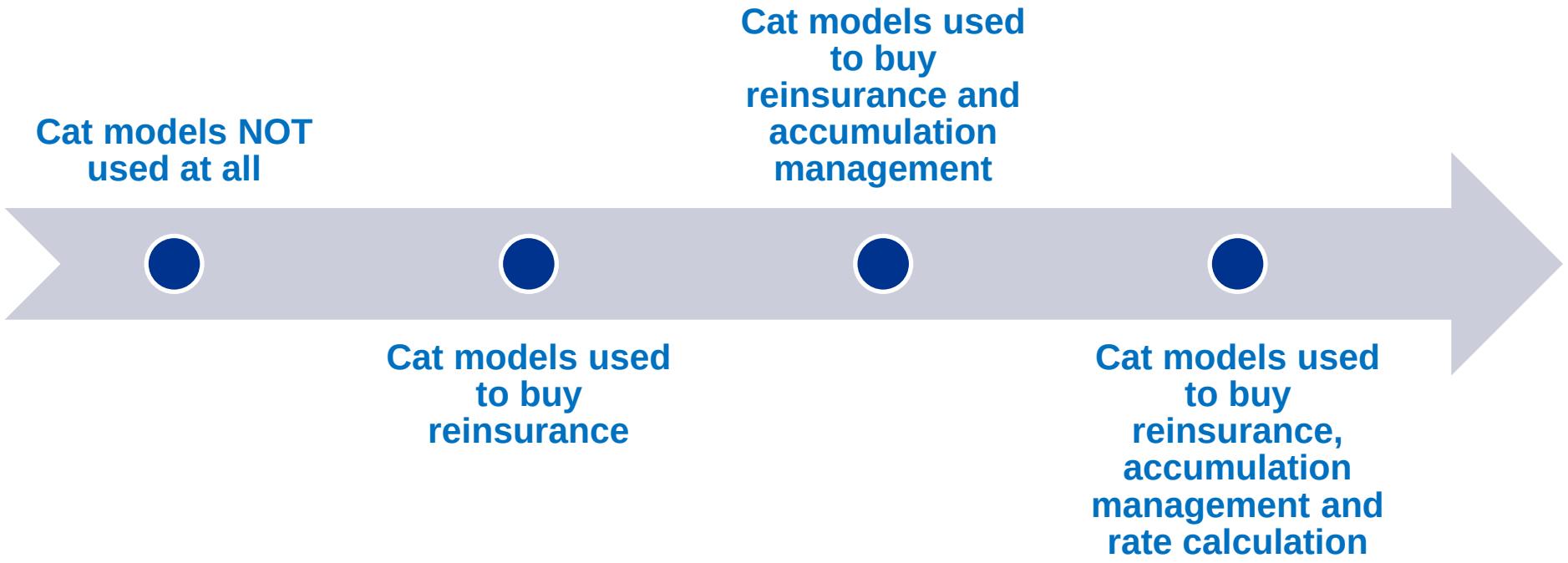
- **Lesson 3:** Demand to have your sample data ran through the model, be creative when designing it, main purpose is: find limitations of the model

- **Lesson 4:** Be really conservative in terms of how long does a new product integration based on a cat model take to implement. Think 3rd parties

- **Lesson 5:** Request the model developers to create custom output and versions of the model if you know what you want

Usage of Cat models in flood risk management

- Where are You in this timeline?

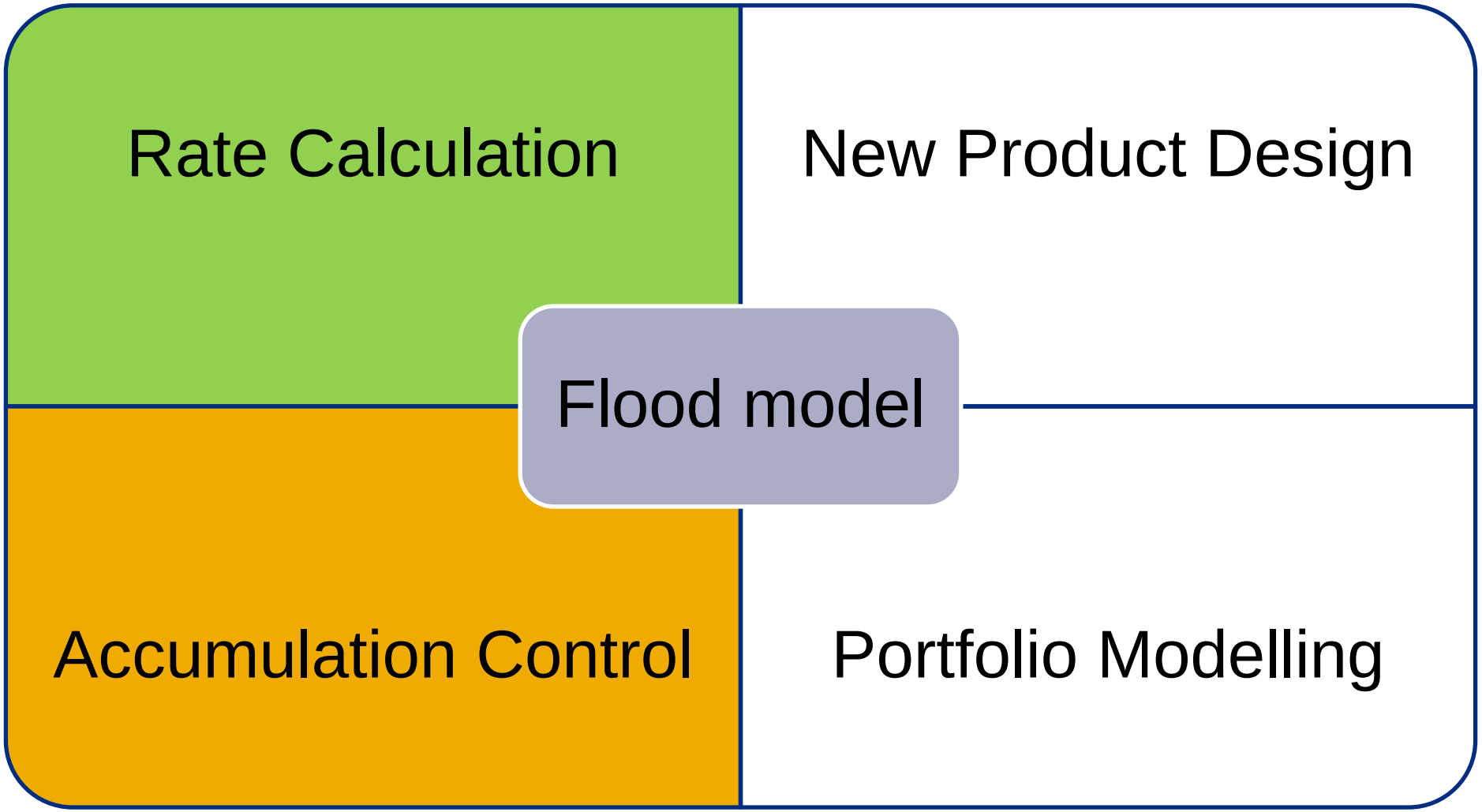


Use of flood cat model: Canada vs. US vs. UK

Use	Canada	US	UK	Czechia
Flood is peril #1	Mostly no but can be locally	Mostly no but can be locally	Mostly no but is frequent	Yes
Flood products available	Com always, Res now available	NFIP, slowly changing to private	Yes, always. Flood Re	Yes (from Communism era)
Presence of flood limits in the products	Mostly no, some for Com	Yes for Com and Res	No for Res	No for Res, Yes for Com
Reinsurance purchase using a flood model	Slowly starting to be part of the mix	Part of the mix, minimal effect	Part of the mix, wind dominant	Yes
Rate calculation using a flood model	Res – now yes, Com – sort of	NFIP – no, starting to be used	Yes, flood maps mainly	Yes, flood maps mainly
Accumulation control using a model	Little	Some	Some	Little
Models developed locally	No (little)	Yes (FEMA)	Yes, non gow.	Yes, non gow.

Section 4: Next steps

4 uses of a flood model: we covered 1



Accumulation control: by region

- Existing: accumulate insured values

OR

- Using our model: accumulate losses

Exposed TIV in Quebec, Manitoba, New Brunswick & BC bring proportionally more losses compared to their exposed TIV share

Zone Name	Exposed TIV	Exp. TIV as % of total	Pure Premium	PP as % of total	PP vs. ETIV
Newfoundland and Labrador	5,597,784,492	1.49%	239,232	0.35%	23%
Prince Edward Island	296,784,663	0.08%	4,671	0.01%	9%
Nova Scotia	9,046,791,873	2.41%	346,624	0.50%	21%
New Brunswick	5,763,710,234	1.53%	1,723,422	2.51%	164%
Quebec	109,931,790,013	29.24%	31,875,629	46.39%	159%
Ontario	146,964,970,963	39.09%	16,639,604	24.21%	62%
Manitoba	11,745,326,355	3.12%	5,307,024	7.72%	247%
Saskatchewan	1,205,095,988	0.32%	59,593	0.09%	27%
Alberta	51,042,498,272	13.58%	5,268,911	7.67%	56%
British Columbia	34,366,483,865	9.14%	7,252,256	10.55%	115%
Yukon	NA	NA	NA	NA	NA
Northwest Territories	NA	NA	NA	NA	NA
Nunavut	NA	NA	NA	NA	NA
Total	**375,961,236,718**	**100%**	**68,716,967**	**100%**	

Accumulation control: by river catchments

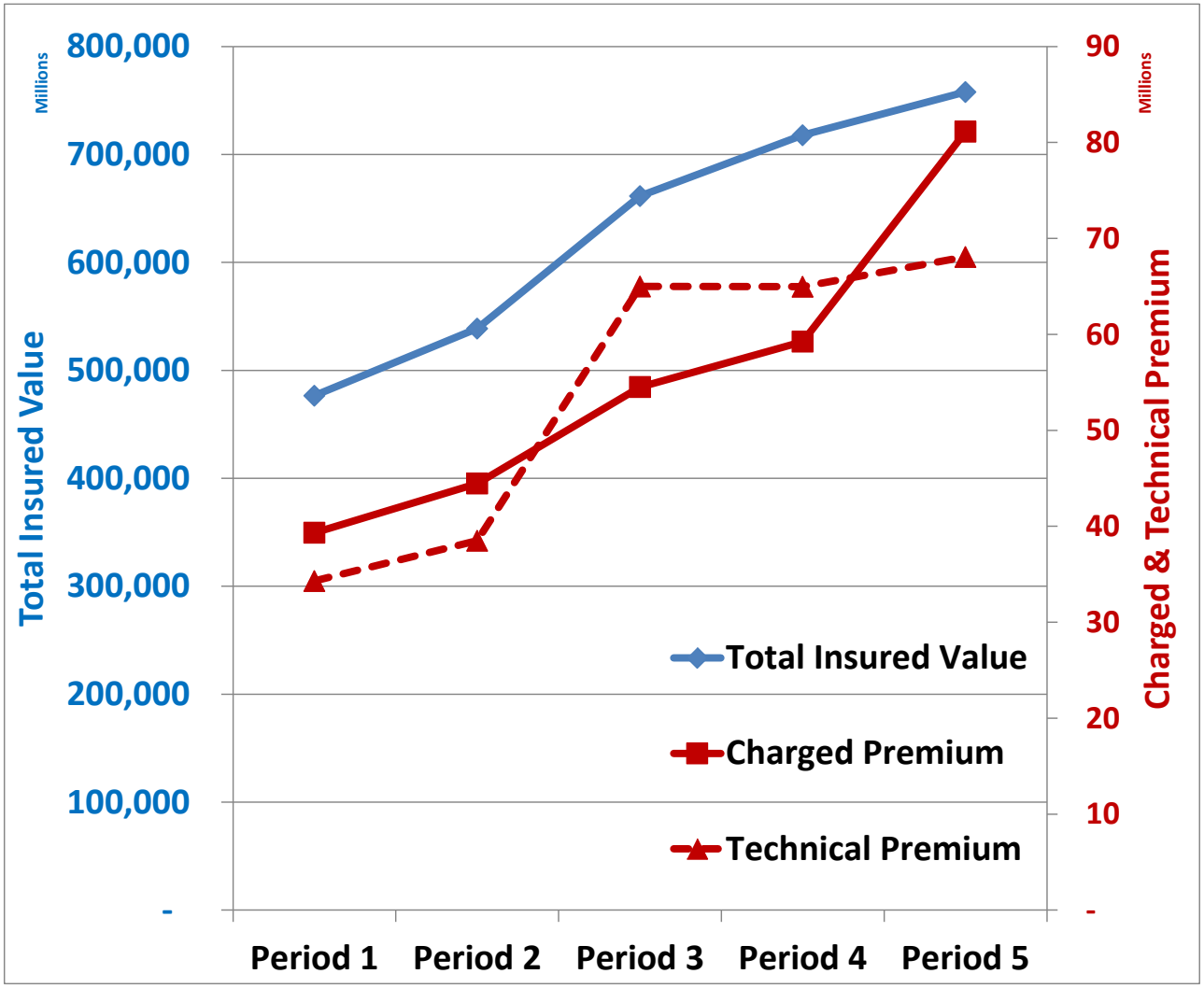
Watershed	Exposed TIV	Exp. TIV as % of Total	Pure Premium - Gross	PP -GR as % of total	PP vs. ETIV
Alberta and BC	374,865,242	1.0%	11,420	0.7%	69%
Alberta and upper Saskatchewan	7,781,072,113	21.6%	524,883	32.8%	152%
Around Ignace city	5,638,163	0.0%	64	0.0%	26%
Around Thunder Bay city	291,600,912	0.8%	2,269	0.1%	18%
Around Wabigoon Lake	7,668,596	0.0%	1	0.0%	0%
Fraser river	4,752,775,660	13.2%	506,080	31.7%	240%
Lower Ontario	10,991,317,759	30.5%	130,007	8.1%	27%
Manitoba and lower Saskatchewan	4,459,775,688	12.4%	194,288	12.2%	98%
Middle Ontario and Quebec	40,282,210	0.1%	208	0.0%	12%
New Brunswick and Nova Scotia	1,478,927,244	4.1%	5,786	0.4%	9%
Newfoundland	127,943,416	0.4%	31	0.0%	1%
Ontario around Lake Superior	61,307,203	0.2%	792	0.0%	29%
St.Lawrence river (Quebec)	3,656,425,585	10.1%	182,922	11.4%	113%
Upper BC and Alberta	1,079,083,825	3.0%	26,696	1.7%	56%
Upper Quebec	43,871,503	0.1%	10,914	0.7%	561%
Vancouver island	528,428,122	1.5%	1,805	0.1%	8%
Others	344,893,580	1.0%	-	0.0%	0%
Total	**36,025,876,819**		**1,598,167**		

Accumulation control: by broker

Group	Total Insured Value		Charged Premium		Technical Premium		TechP vs TIV	TechP vs ChP	
Broker 1	747,385,991	39%	137,719	26%	79,842	16%	41%	61%	✓
Broker 2	310,480,028	16%	167,909	32%	123,829	25%	154%	78%	✓
Broker 3	531,090,895	28%	192,748	37%	228,745	46%	167%	125%	✗
Broker 4	338,843,715	18%	25,859	5%	66,228	13%	76%	269%	✗

Accumulation control: constant monitoring

- Tracking
  - TIV
  - Charged premium
  - Technical premium
  - 1 in 100 years loss
- Quarterly, monthly



Questions?

Thanks for your attention

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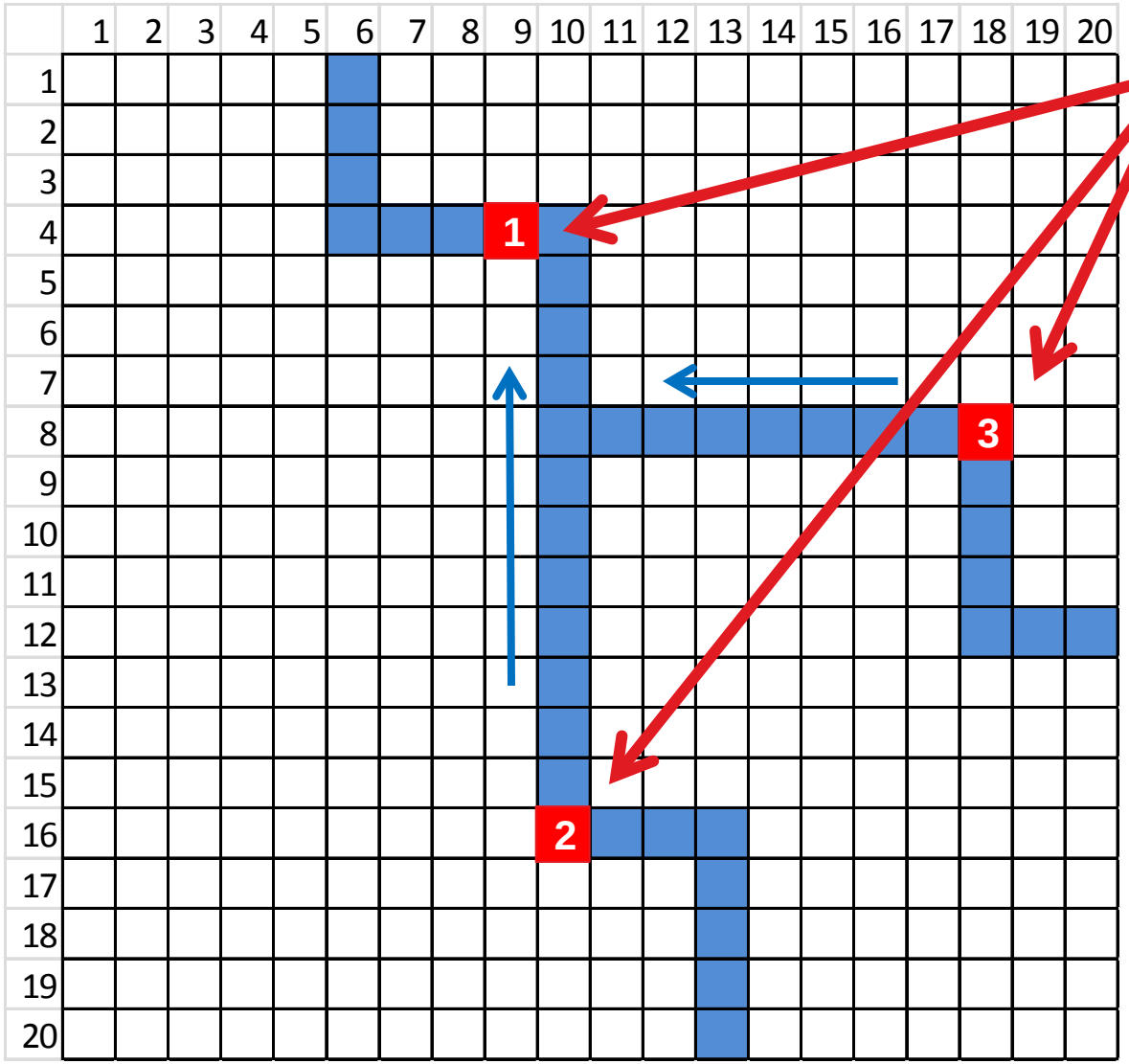
Appendix: Flood map vs. probabilistic model

Flood map – the process



3 gauge station with 30 years of observed data

1		2		3	
Year	Discharge (m^3/s)	Year	Discharge (m^3/s)	Year	Discharge (m^3/s)
2015	341	2015	205	2015	136
2014	463	2014	278	2014	185
2013	381	2013	229	2013	152
2012	539	2012	323	2012	216
2011	377	2011	226	2011	151
2010	953	2010	572	2010	381
2009	691	2009	415	2009	276
2008	411	2008	247	2008	164
2007	305	2007	183	2007	122
2006	482	2006	289	2006	193
2005	386	2005	232	2005	154
2004	857	2004	514	2004	343
2003	850	2003	510	2003	340
2002	45	2002	27	2002	18
2001	821	2001	493	2001	328
2000	86	2000	52	2000	34
1999	628	1999	377	1999	251
1998	175	1998	105	1998	70
1997	913	1997	548	1997	365
1996	955	1996	573	1996	382
1995	62	1995	37	1995	25
1994	829	1994	497	1994	332
1993	682	1993	409	1993	273
1992	817	1992	490	1992	327
1991	423	1991	254	1991	169
1990	584	1990	350	1990	234
1989	373	1989	224	1989	149
1988	570	1988	342	1988	228
1987	800	1987	480	1987	320
1986	70	1986	42	1986	28

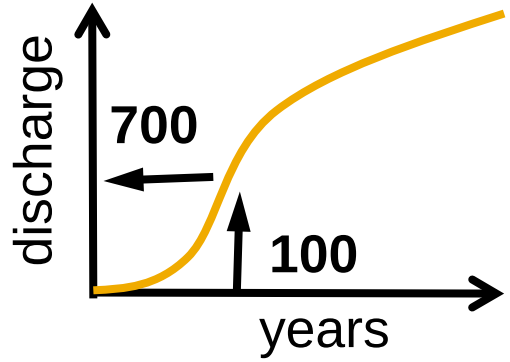
Flood map – the process (per station)

1

Year	Discharge (m^3/s)
2015	341
2014	463
2013	381
2012	539
2011	377
2010	953
2009	691
2008	411
2007	305
2006	482
2005	386
2004	857
2003	850
2002	45
2001	821
2000	86
1999	628
1998	175
1997	913
1996	955
1995	62
1994	829
1993	682
1992	817
1991	423
1990	584
1989	373
1988	570
1987	800
1986	70

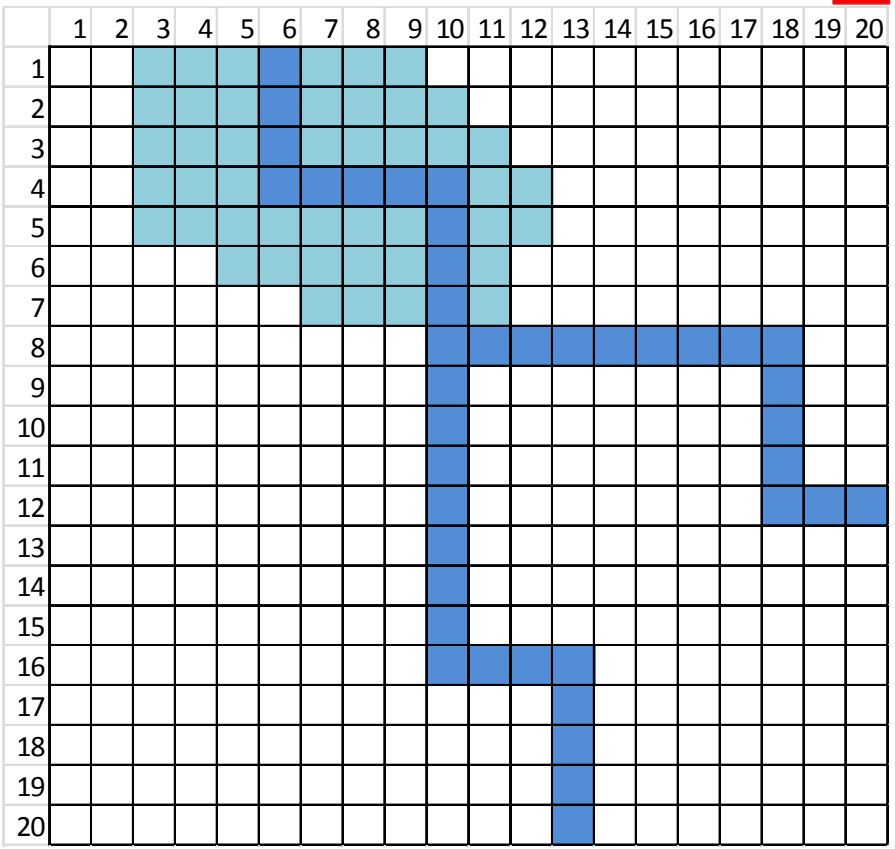
1

Calculate “design flows”

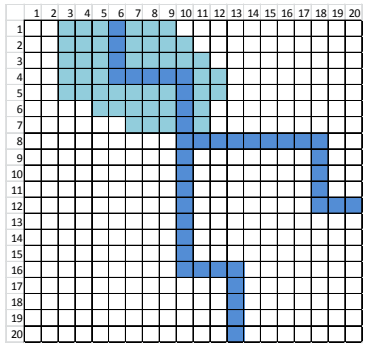


Create flood map for 1 in 100 years discharge

1



Flood map – the process (for all stations)



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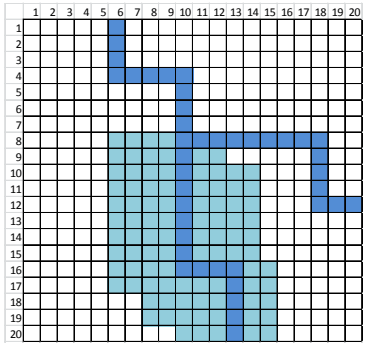

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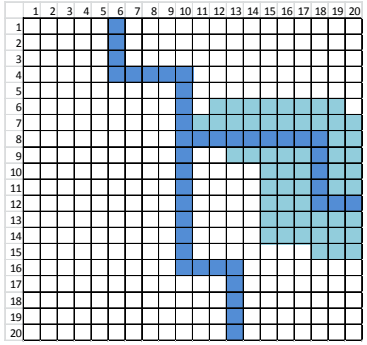
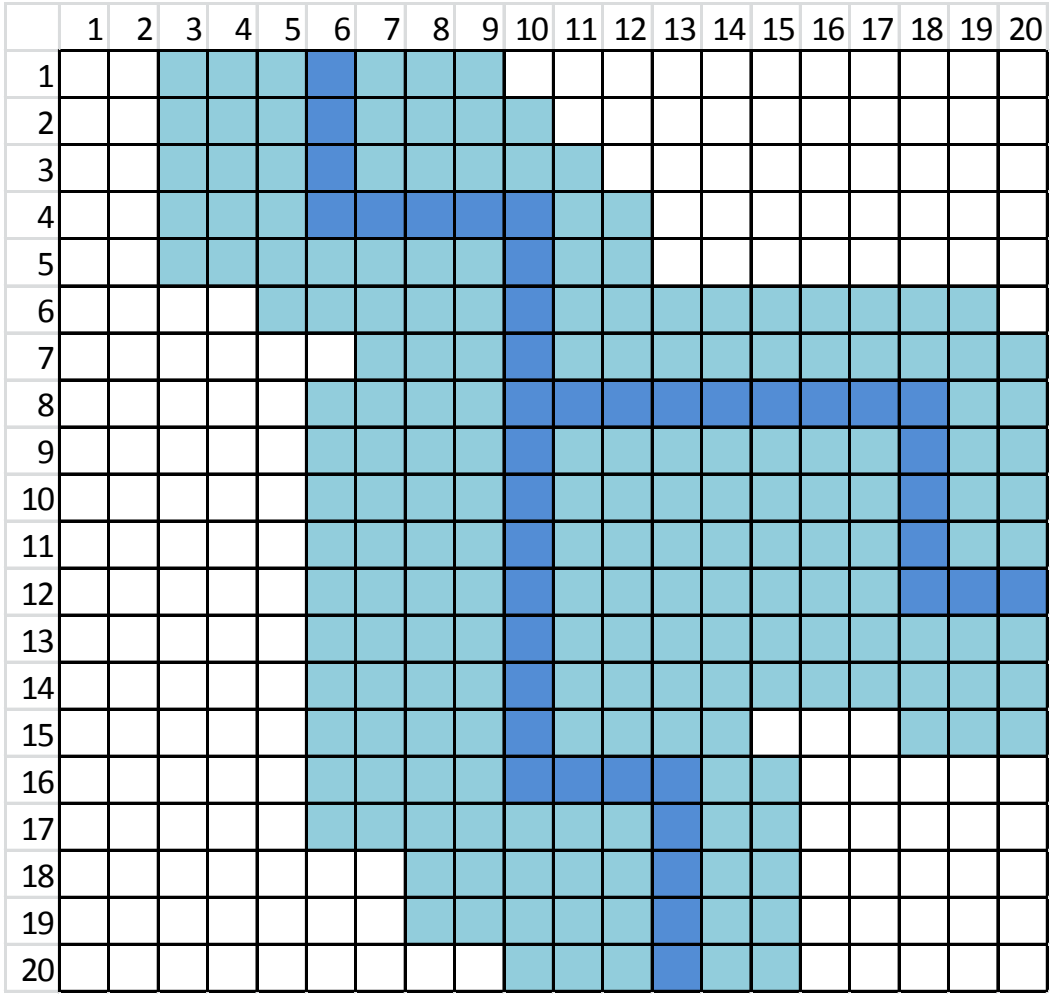
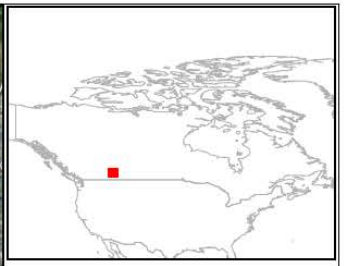


3

Flood map for 1 in 100 years discharge (all stations)



Flood map – Calgary



Grid Cell Flood Hazard

Hazard (1 in 100 years)

Flood Depth [m]

- < 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- > 4.1

0 2 4

Kilometers

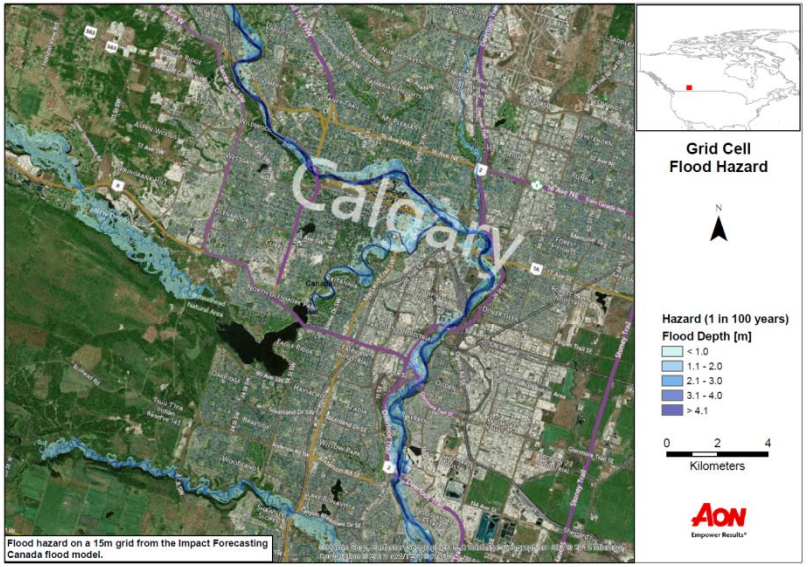
AON Empower Results®

Flood map – Calgary (nice visualisation but…)

1 in 250 years flood map for Calgary visualised in Google Earth, source: Impact Forecasting

Flood map – summary

- Flood (inundation) depth can be included
- Available for a range of return periods
  - 10 to 10,000 years
- **Advantages**
  - Simple to use
  - Simpler to develop
- **Disadvantages**
  - Doesn't include correlation between stations
  - Does NOT express loss in any sense
  - Does NOT give rate indication
  - Is NOT probabilistic

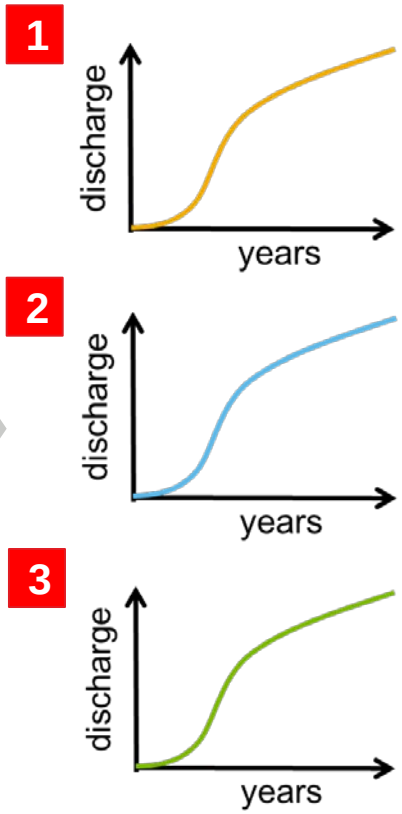


Probabilistic model – interaction between stations

3 gauge station with 30 years of observed data

1		2		3	
Year	Discharge (m^3/s)	Year	Discharge (m^3/s)	Year	Discharge (m^3/s)
2015	341	2015	205	2015	136
2014	463	2014	278	2014	185
2013	381	2013	229	2013	152
2012	539	2012	323	2012	216
2011	377	2011	226	2011	151
2010	953	2010	572	2010	381
2009	691	2009	415	2009	276
2008	411	2008	247	2008	164
2007	305	2007	183	2007	122
2006	482	2006	289	2006	193
2005	386	2005	232	2005	154
2004	857	2004	514	2004	343
2003	850	2003	510	2003	340
2002	45	2002	27	2002	18
2001	821	2001	493	2001	328
2000	86	2000	52	2000	34
1999	628	1999	377	1999	251
1998	175	1998	105	1998	70
1997	913	1997	548	1997	365
1996	955	1996	573	1996	382
1995	62	1995	37	1995	25
1994	829	1994	497	1994	332
1993	682	1993	409	1993	273
1992	817	1992	490	1992	327
1991	423	1991	254	1991	169
1990	584	1990	350	1990	234
1989	373	1989	224	1989	149
1988	570	1988	342	1988	228
1987	800	1987	480	1987	320
1986	70	1986	42	1986	28

Design flows



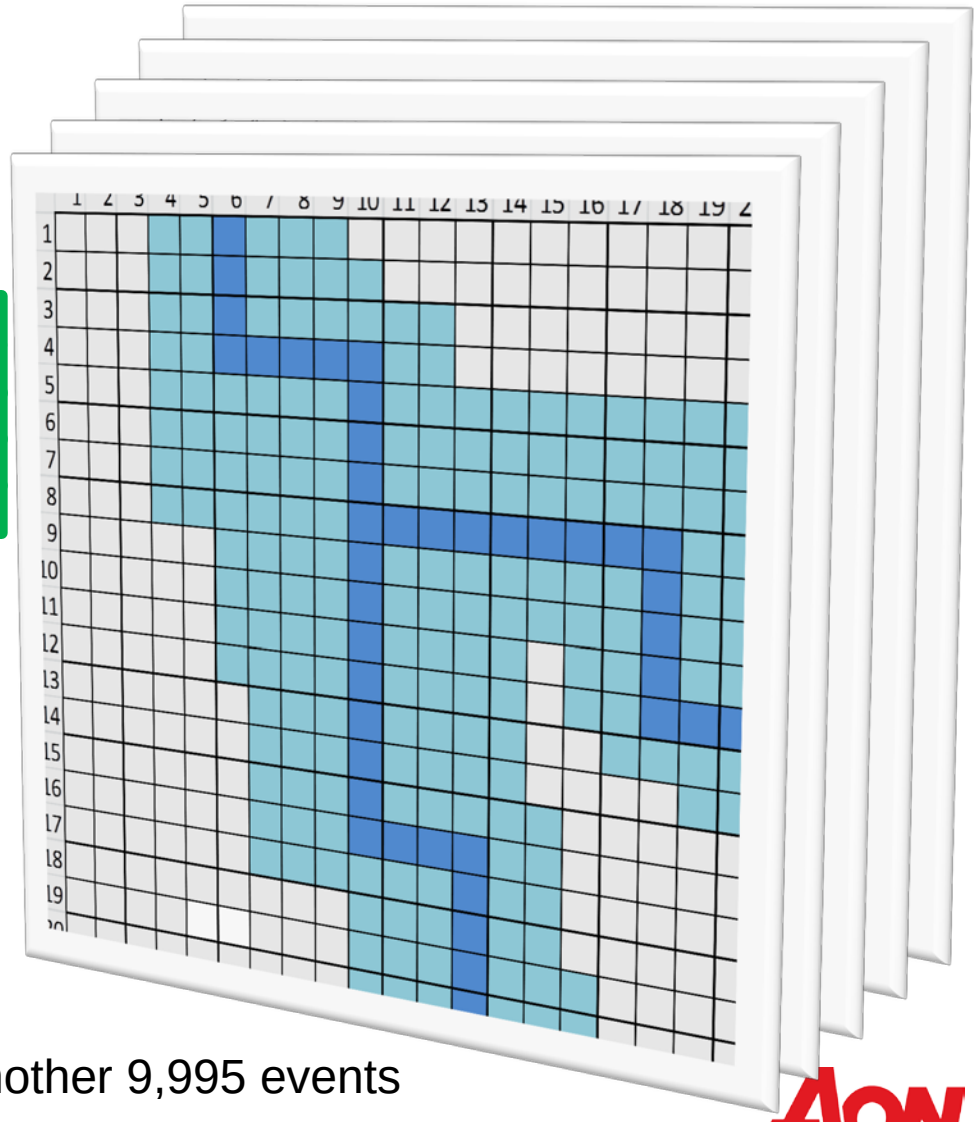
Add correlation

	1	2	3
1	1	0.9	0.8
2	0.9	1	0.6
3	0.8	0.6	1

Probabilistic model – interaction between stations

Generate 10,000 realistic events for all stations

	1	2	3
Event	**Discharge (m^3/s)**	**Discharge (m^3/s)**	**Discharge (m^3/s)**
1	63	38	25
2	866	520	346
3	964	578	386
4	332	199	133
5	355	213	142
6	142	85	57
7	220	132	88
8	561	337	224
9	713	428	285
10	491	295	196
…	…	…	…
10,000	581	349	232

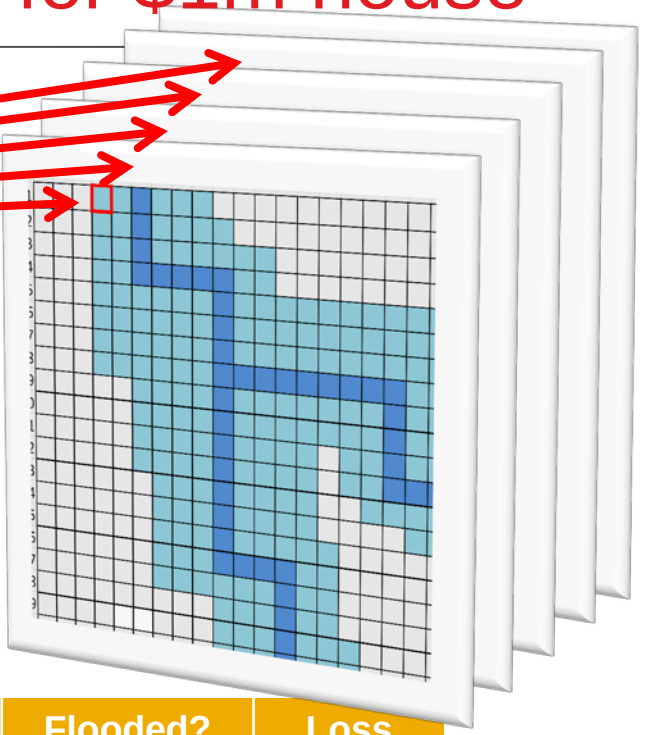


And another 9,995 events

Probabilistic model – calculate loss for $1m house

Calculate loss for every event for cell **4-1**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1	9-1	10-1	11-1	12-1	13-1	14-1	15-1	16-1	17-1	18-1	19-1	20-1
2	1-2	2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2	11-2	12-2	13-2	14-2	15-2	16-2	17-2	18-2	19-2	20-2
3	1-3	2-3	3-3	4-3	5-3	6-3	7-3	8-3	9-3	10-3	11-3	12-3	13-3	14-3	15-3	16-3	17-3	18-3	19-3	20-3
4	1-4	2-4	3-4	4-4	5-4	6-4	7-4	8-4	9-4	10-4	11-4	12-4	13-4	14-4	15-4	16-4	17-4	18-4	19-4	20-4
5	1-5	2-5	3-5	4-5	5-5	6-5	7-5	8-5	9-5	10-5	11-5	12-5	13-5	14-5	15-5	16-5	17-5	18-5	19-5	20-5
6	1-6	2-6	3-6	4-6	5-6	6-6	7-6	8-6	9-6	10-6	11-6	12-6	13-6	14-6	15-6	16-6	17-6	18-6	19-6	20-6
7	1-7	2-7	3-7	4-7	5-7	6-7	7-7	8-7	9-7	10-7	11-7	12-7	13-7	14-7	15-7	16-7	17-7	18-7	19-7	20-7
8	1-8	2-8	3-8	4-8	5-8	6-8	7-8	8-8	9-8	10-8	11-8	12-8	13-8	14-8	15-8	16-8	17-8	18-8	19-8	20-8
9	1-9	2-9	3-9	4-9	5-9	6-9	7-9	8-9	9-9	10-9	11-9	12-9	13-9	14-9	15-9	16-9	17-9	18-9	19-9	20-9
10	1-10	2-10	3-10	4-10	5-10	6-10	7-10	8-10	9-10	10-10	11-10	12-10	13-10	14-10	15-10	16-10	17-10	18-10	19-10	20-10
11	1-11	2-11	3-11	4-11	5-11	6-11	7-11	8-11	9-11	10-11	11-11	12-11	13-11	14-11	15-11	16-11	17-11	18-11	19-11	20-11
12	1-12	2-12	3-12	4-12	5-12	6-12	7-12	8-12	9-12	10-12	11-12	12-12	13-12	14-12	15-12	16-12	17-12	18-12	19-12	20-12
13	1-13	2-13	3-13	4-13	5-13	6-13	7-13	8-13	9-13	10-13	11-13	12-13	13-13	14-13	15-13	16-13	17-13	18-13	19-13	20-13
14	1-14	2-14	3-14	4-14	5-14	6-14	7-14	8-14	9-14	10-14	11-14	12-14	13-14	14-14	15-14	16-14	17-14	18-14	19-14	20-14
15	1-15	2-15	3-15	4-15	5-15	6-15	7-15	8-15	9-15	10-15	11-15	12-15	13-15	14-15	15-15	16-15	17-15	18-15	19-15	20-15
16	1-16	2-16	3-16	4-16	5-16	6-16	7-16	8-16	9-16	10-16	11-16	12-16	13-16	14-16	15-16	16-16	17-16	18-16	19-16	20-16
17	1-17	2-17	3-17	4-17	5-17	6-17	7-17	8-17	9-17	10-17	11-17	12-17	13-17	14-17	15-17	16-17	17-17	18-17	19-17	20-17
18	1-18	2-18	3-18	4-18	5-18	6-18	7-18	8-18	9-18	10-18	11-18	12-18	13-18	14-18	15-18	16-18	17-18	18-18	19-18	20-18
19	1-19	2-19	3-19	4-19	5-19	6-19	7-19	8-19	9-19	10-19	11-19	12-19	13-19	14-19	15-19	16-19	17-19	18-19	19-19	20-19
20	1-20	2-20	3-20	4-20	5-20	6-20	7-20	8-20	9-20	10-20	11-20	12-20	13-20	14-20	15-20	16-20	17-20	18-20	19-20	20-20



Event	Flooded?	Loss
1	No	0
2	Yes	300,000
3	Yes	350,000
4	Yes	100,000
5	Yes	120,000
….	…	…
10,000	No	0

And another 9,995 events

Probabilistic model – calculate Pure Premium (AAL)

1. Calculate Probability * Loss

2. Sum this to get Pure Premium (Average Annual Loss) for **cell 4-1**

3. Express $523 as % of total insured value

Event	Flooded?	Loss	Probability	P * Loss ($)	
1	No	**0**	0.0001	0	
2	Yes	**300,000**	0.0001	30	
3	Yes	**350,000**	0.0001	35	
4	Yes	**100,000**	0.0001	10	
5	Yes	**120,000**	0.0001	12	
….	…	**…**	….	…	
10,000	No	**0**	0.0001	0	
			Pure P.	**$ 523**	**0.0523%**

Probabilistic model – repeat for all cells

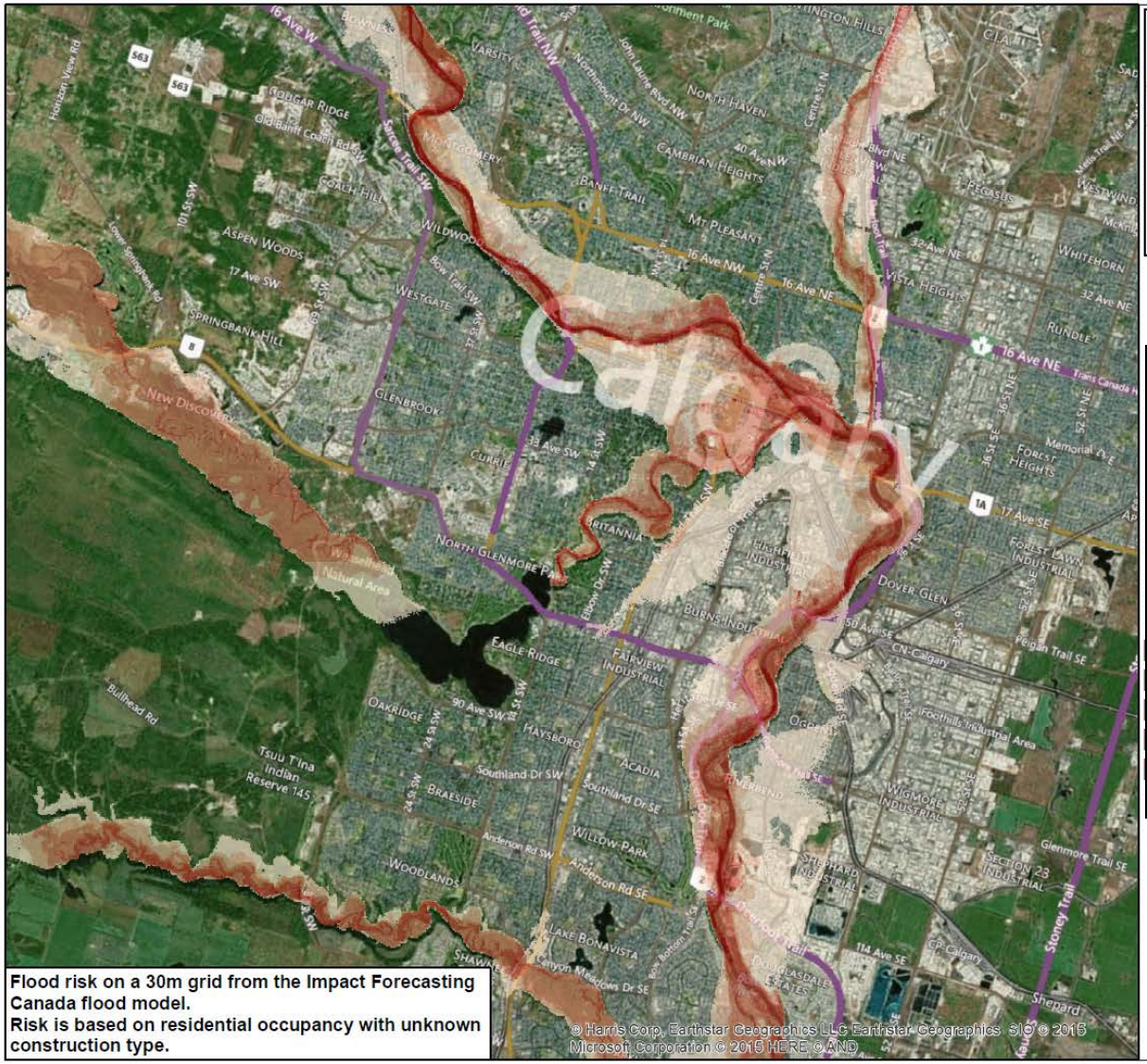
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	0	114	**523**	714		721	728	528	0	0	0	0	0	0	0	0	0	0	0
2	0	0	110	549	679		728	672	507	0	0	0	0	0	0	0	0	108	111	112
3	0	0	116	502	735		735	700	714	502	539	518	523	106	107	108	114	114	112	109
4	0	0	105	502	721						693	518	544	544	502	533	549	502	107	110
5	0	0	109	518	665	672	700	728	665		735	672	686	665	544	533	549	513	528	109
6	0	0	106	507	497	672	728	672	735		700	707	735	714	507	528	502	518	544	518
7	0	0	114	518	528	518	549	686	728		672	665	665	714	707	728	693	700	693	518
8	0	0	112	114	109	0	533	665	665										700	544
9	0	0	0	0	116	109	502	707	693		693	721	700	707	686	700	672		707	533
10	0	0	0	0	111	108	513	693	714		686	672	539	502	497	721	686		707	679
11	0	0	0	0	112	113	513	700	721		735	672	533	507	513	728	672		665	721
12	0	0	0	0	113	113	528	679	686		679	672	502	528	502	693	714			
13	0	0	0	0	108	105	523	665	735		686	693	539	513	544	714	693	721	672	700
14	0	0	0	0	108	113	523	672	707		721	721	523	533	497	513	544	544	523	707
15	0	0	0	0	106	114	523	665	707		714	735	721	707	735	539	513	528	523	539
16	0	0	0	0	110	108	502	533	693					686	679	539	539	518	539	502
17	0	0	0	0	105	105	523	533	700	665	721	686		707	679	539	513	105	107	105
18	0	0	0	0	114	112	116	533	539	518	707	672		693	735	539	502	108	108	109
19	0	0	0	0	0	0	0	105	518	544	693	735		686	707	539	507	108	108	105
20	0	0	0	0	0	0	0	112	513	544	735	672		672	693	518	518	113	0	0

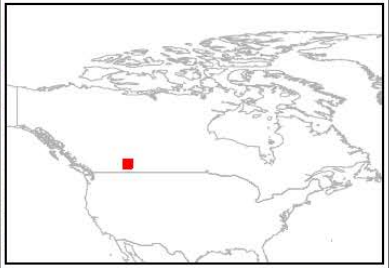
Probabilistic model – express as % of TIV

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.05%	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.05%	0	0	0	0	0	0	0	0	0.01%	0.01%	0.01%
3	0	0	0.01%	0.05%	0.07%		0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
4	0	0	0.01%	0.05%	0.07%						0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.01%	0.01%
5	0	0	0.01%	0.05%	0.07%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.01%
6	0	0	0.01%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
7	0	0	0.01%	0.05%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.05%
8	0	0	0.01%	0.01%	0.01%	0.00%	0.05%	0.07%	0.07%										0.07%	0.05%
9	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%		0.07%	0.05%
10	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%
11	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%
12	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%			
13	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%	0.07%
14	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.07%
15	0	0	0	0	0.01%	0.01%	0.05%	0.07%	0.07%		0.07%	0.07%	0.07%	0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%
16	0	0	0	0	0.01%	0.01%	0.05%	0.05%	0.07%					0.07%	0.07%	0.05%	0.05%	0.05%	0.05%	0.05%
17	0	0	0	0	0.01%	0.01%	0.05%	0.05%	0.07%	0.07%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
18	0	0	0	0	0.01%	0.01%	0.01%	0.05%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
19	0	0	0	0	0	0	0	0.01%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0.01%	0.01%
20	0	0	0	0	0	0	0	0.01%	0.05%	0.05%	0.07%	0.07%		0.07%	0.07%	0.05%	0.05%	0.01%	0	0

- Do the same for all
  - Occupancies
  - Constructions
  - Number of stories classes
  - Presence of basement
  - Etc.

Probabilistic model – pure premium for $300k house





Residential Grid Cell Flood Risk

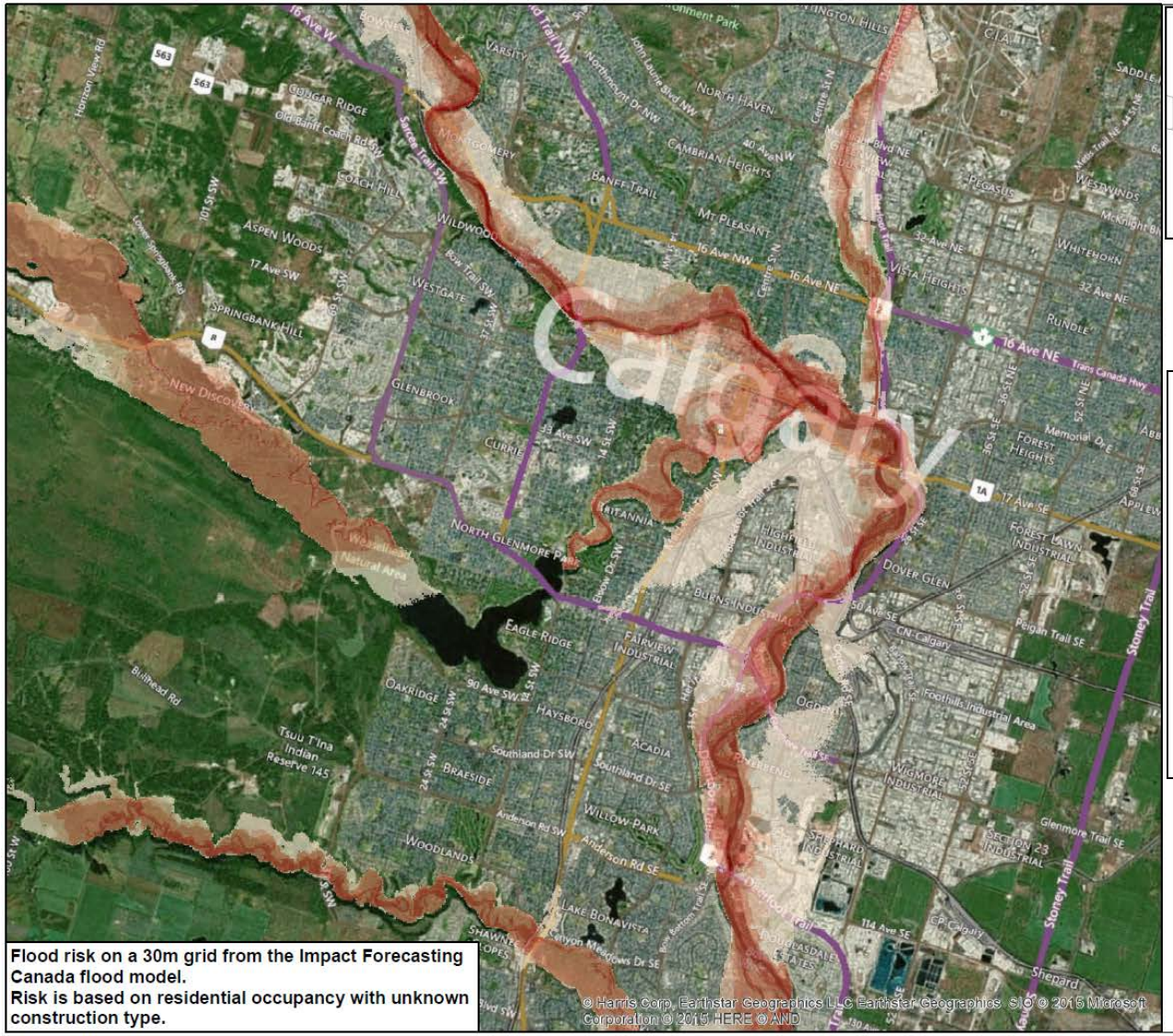
Pure Premium (Average Annual Loss)
Building Sum Insured 300,000 CAD

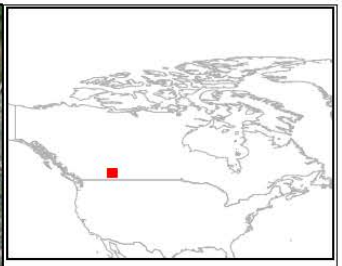
- < 200
- 201 - 400
- 401 - 600
- 601 - 1,000
- > 1,001

0 2 4
Kilometers

Impact Forecasting
AON
Empower Results®

Probabilistic model – pure premium as % of TIV





Residential Grid Cell Flood Risk

Pure Premium (AAL)
(as % of TSI per Zone)

- < 0.04
- 0.05 - 0.1
- 0.11 - 0.2
- 0.21 - 0.4
- > 0.41

0 2 4
Kilometers

AON
Empower Results®

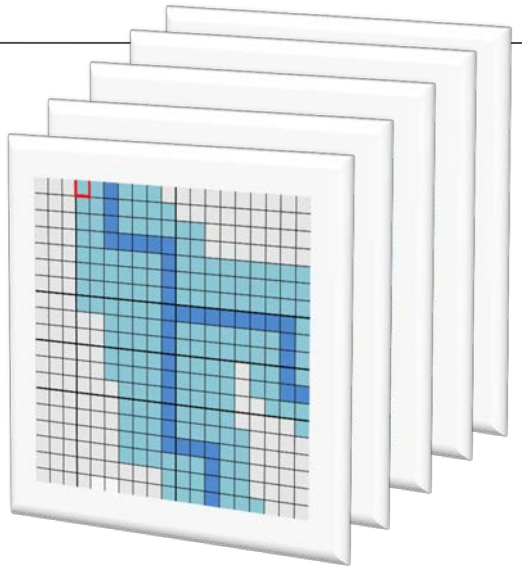
Probabilistic model – summary

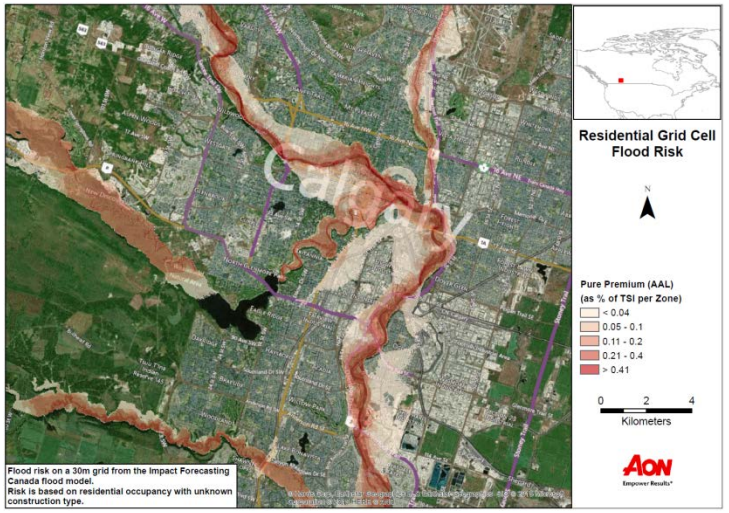
- Pure premium expressed as % of insured value

- Depends on property parameters

- **Advantages**
  - Includes loss
  - Gives rate indication
  - Is probabilistic
  - Includes correlation

- **Disadvantages**
  - Takes longer to develop
  - Needs to be understood and used with care





Flood map vs. probabilistic model – summary

Characteristics	Flood Map	Probabilistic model
Development effort	Shorter	Longer
Simplicity of use	Simple, but…	Simple, but…
Helps to calculate rate	No	Yes
Enables to evaluate effect of insurance conditions	No	Yes
Probabilistic	No	Yes
Inclusion of correlation	No	Yes

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