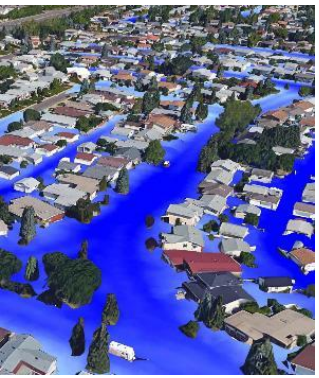
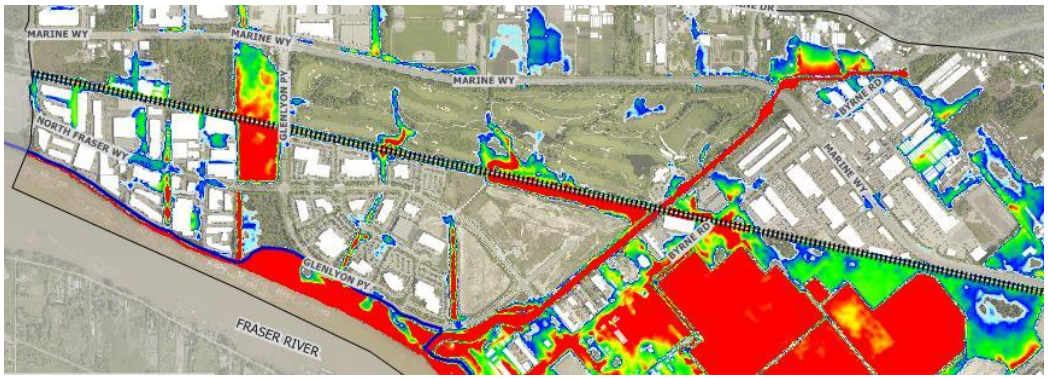
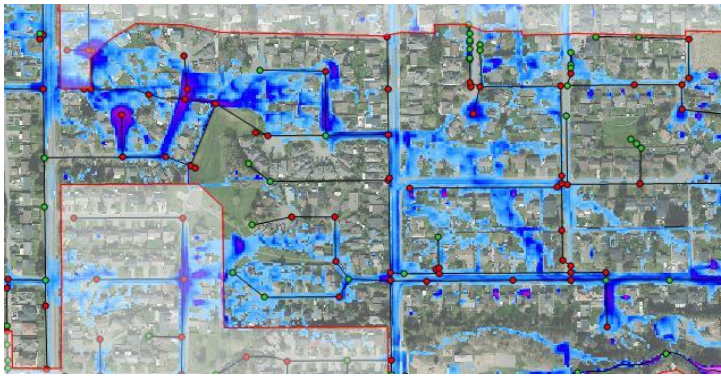
Associated Engineering

CANADA'S BEST MANAGED COMPANIES Platinum member







Urban Flooding

Assessing Climate Change and Extreme Rainfall Events

Andrew Wiens, P.Eng.

January 26, 2018

Outline

Outline

- Case Study:
  - City of Surrey: Climate Change Rainfall Adaptation Strategy
- Other Project Examples:
  - City of Burnaby
- Insurance & DFA
- Summary

Special Thanks to:

CITY OF SURREY
the future lives here.

City of Burnaby

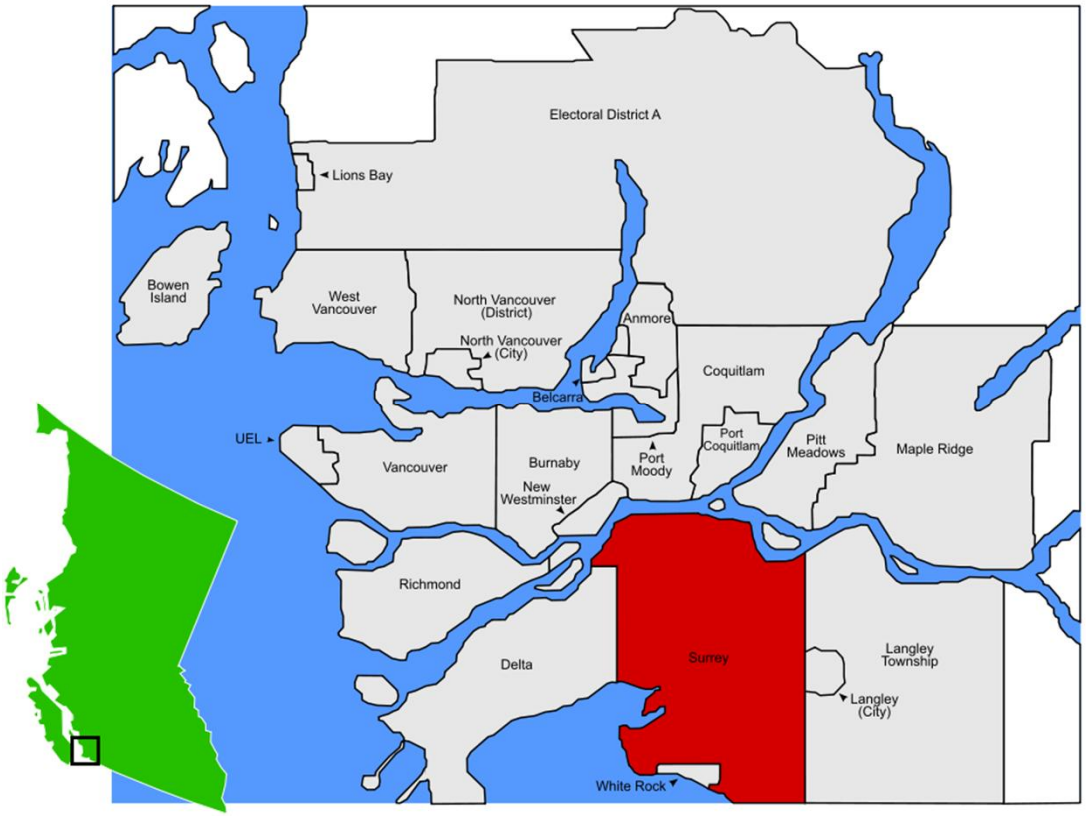
Case Study:
Climate Change Rainfall Adaptation Strategy

CITY OF SURREY
the future lives here.

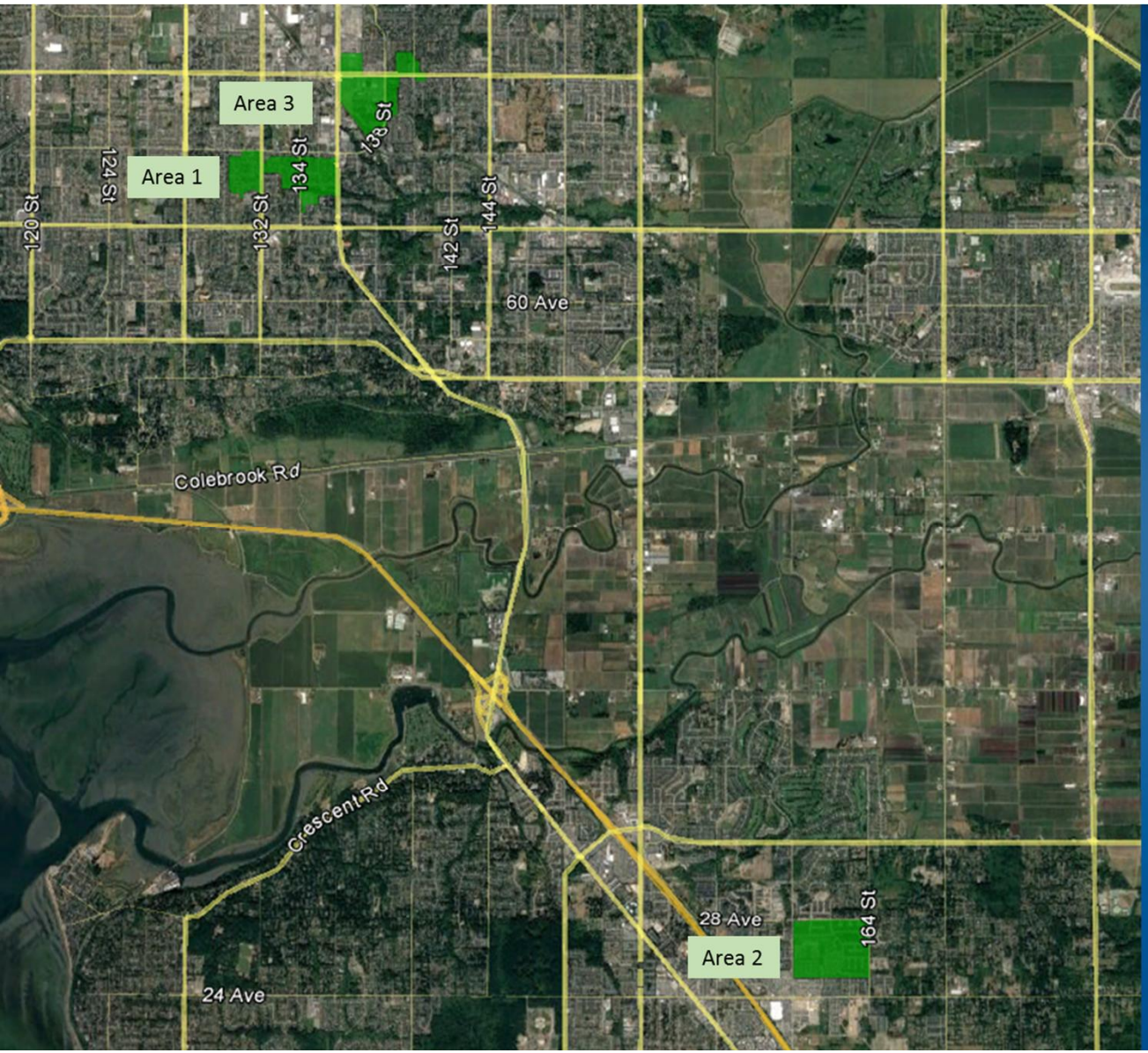
Project Objectives

1	2	3	4
Review impacts of City's climate change rainfall projections as applied to *three case study* areas	Evaluate performance of stormwater system	Develop and evaluate adaptation measures	Develop screening level assessment to identify high risk areas

City of Surrey



- Area: 317 sq.km.
- Population: over 500,000



Study Areas

Area 1:

- Single Family Residential Housing
- Houses and storm infrastructure built during the 1970's and 1980's
- Some basements

Area 2:

- Single Family Residential Housing
- Houses and storm infrastructure built during the early 2000's
- Some basements

Area 3:

- Commercial/Multi-Family Housing
- Few basements

Future Climate Change Projections

Average increase in projected rainfall statistics:

Planning Horizon	Increase Relative to 2013 IDF
2030's	20%
2050's	35%
2080's	68%

Why does this matter?

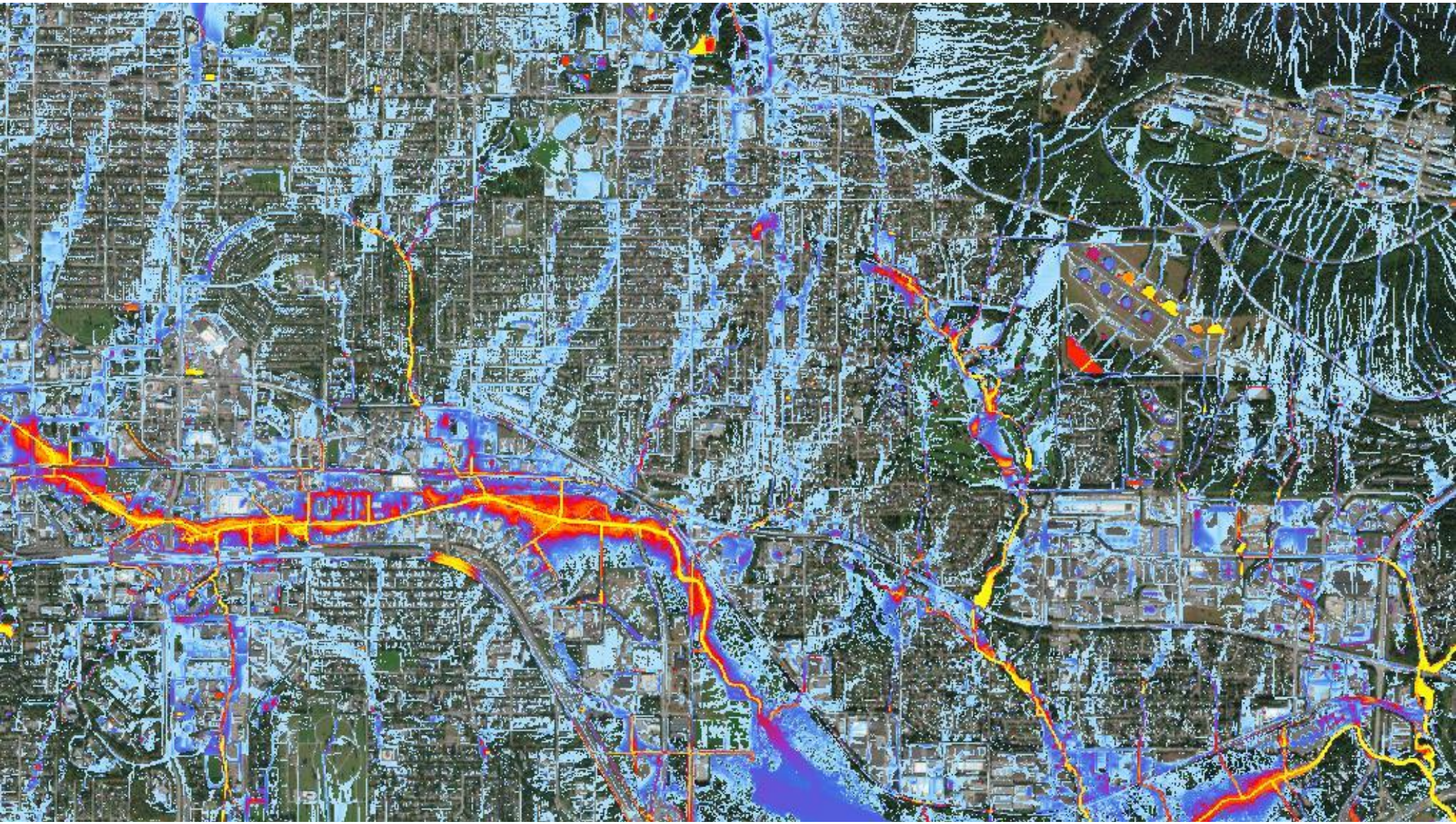
Why does this matter?

- Key objective is not pipe sizing –
  it is identifying impact to society
  (economic losses)

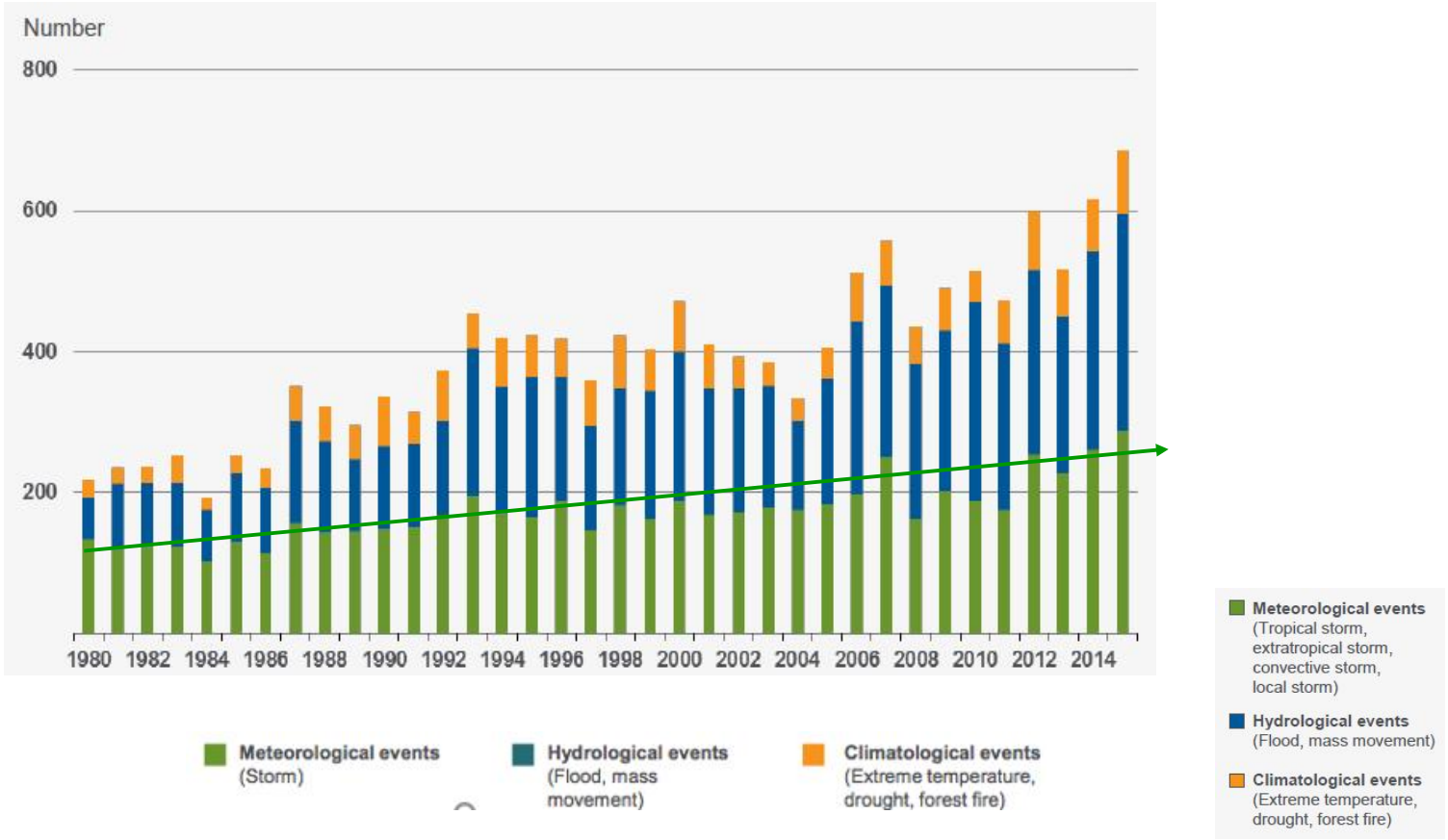
- River & coastal flood risk is well understood;
  rainfall flooding risk not so much...

Why does this matter?

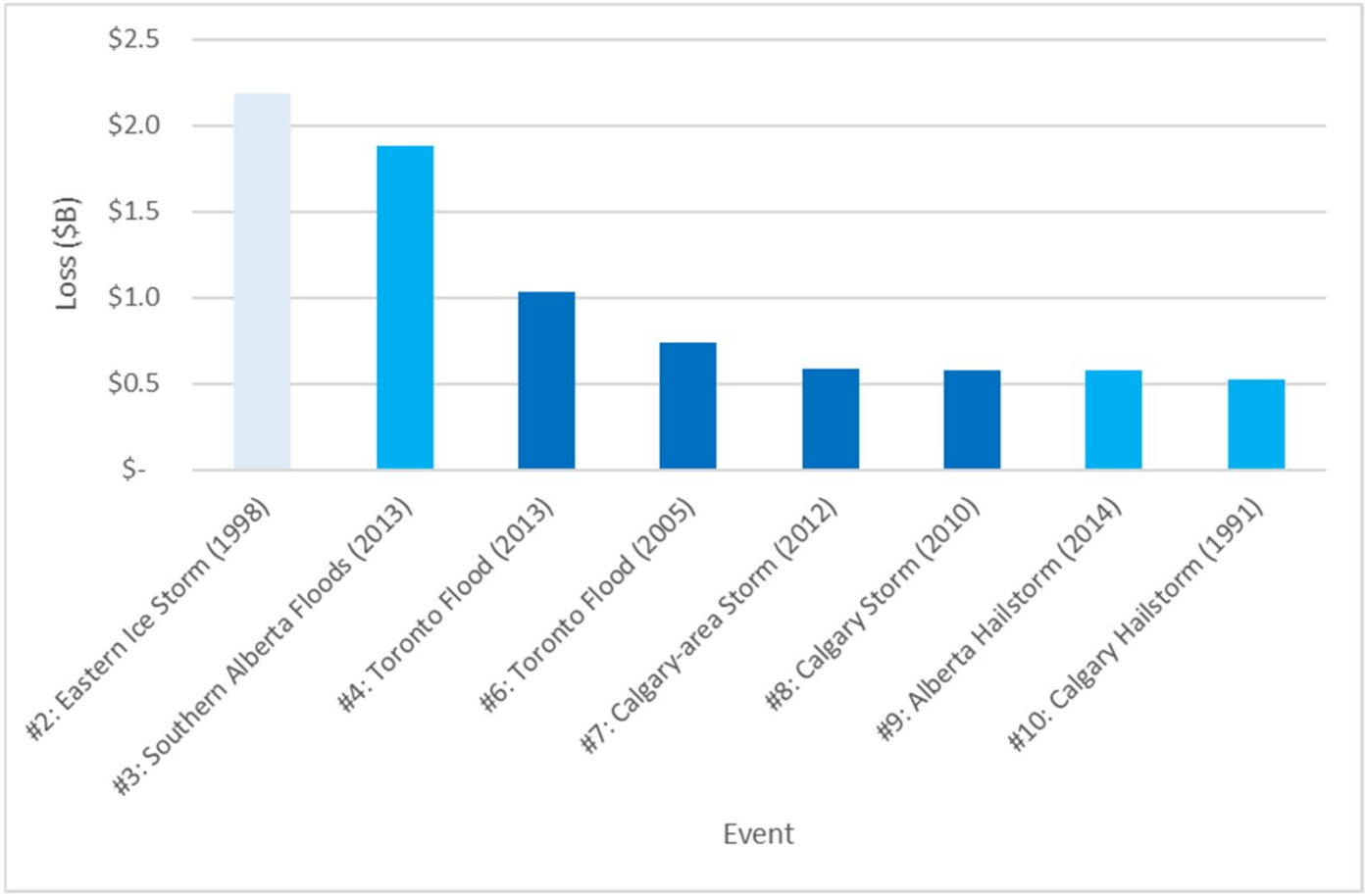
Why does this matter?



Weather-related Loss Events Worldwide 1980-2015

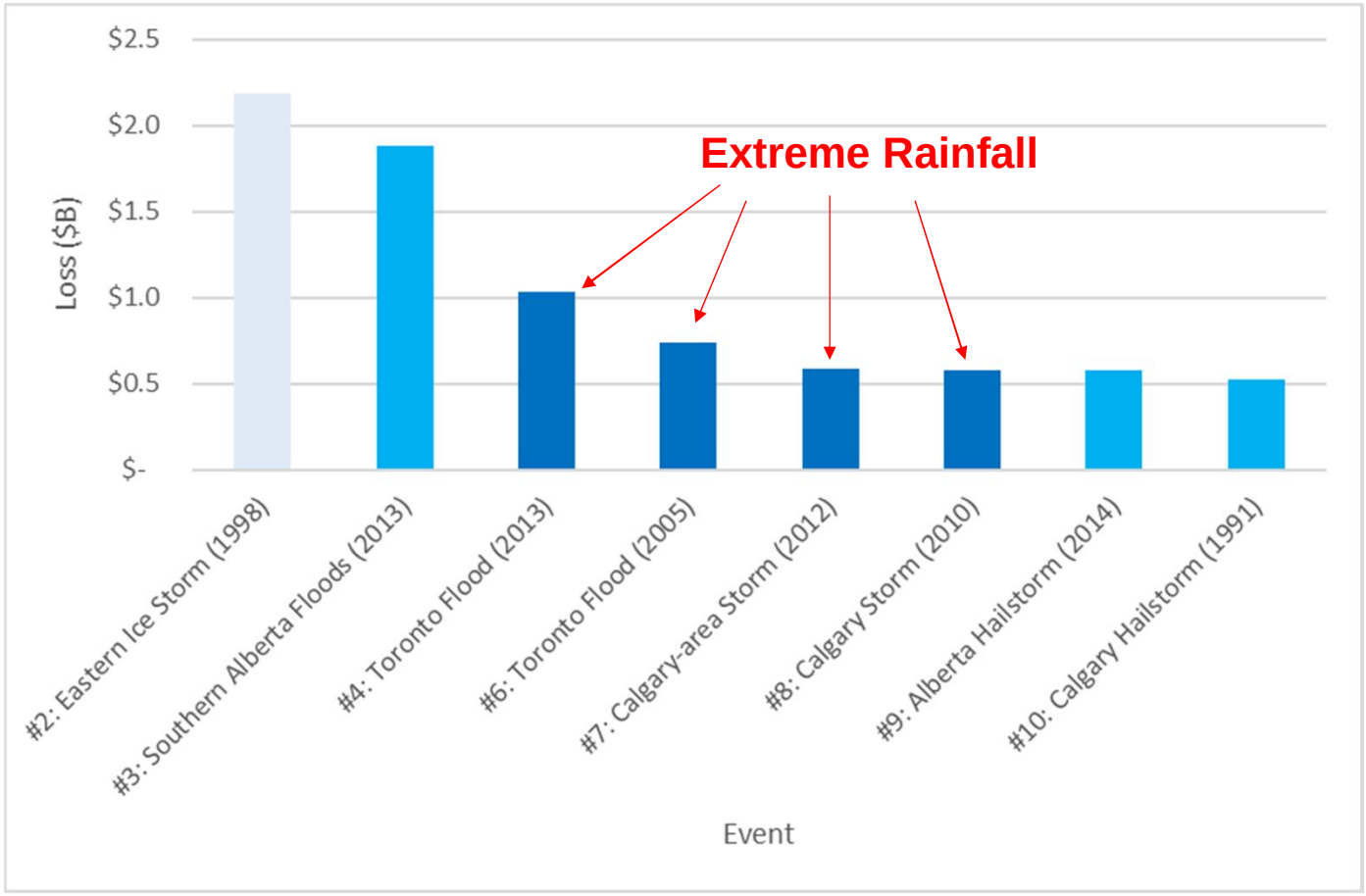


Top Flood/Storm Events for Insurance Payouts



Loss & Loss Adjustment Expenses
Source: IBC Facts Book, PCS, CatIQ, Swiss Re, Munich Re & Deloitte
Values in 2015 $ CAN

Top Flood/Storm Events for Insurance Payouts



Loss & Loss Adjustment Expenses
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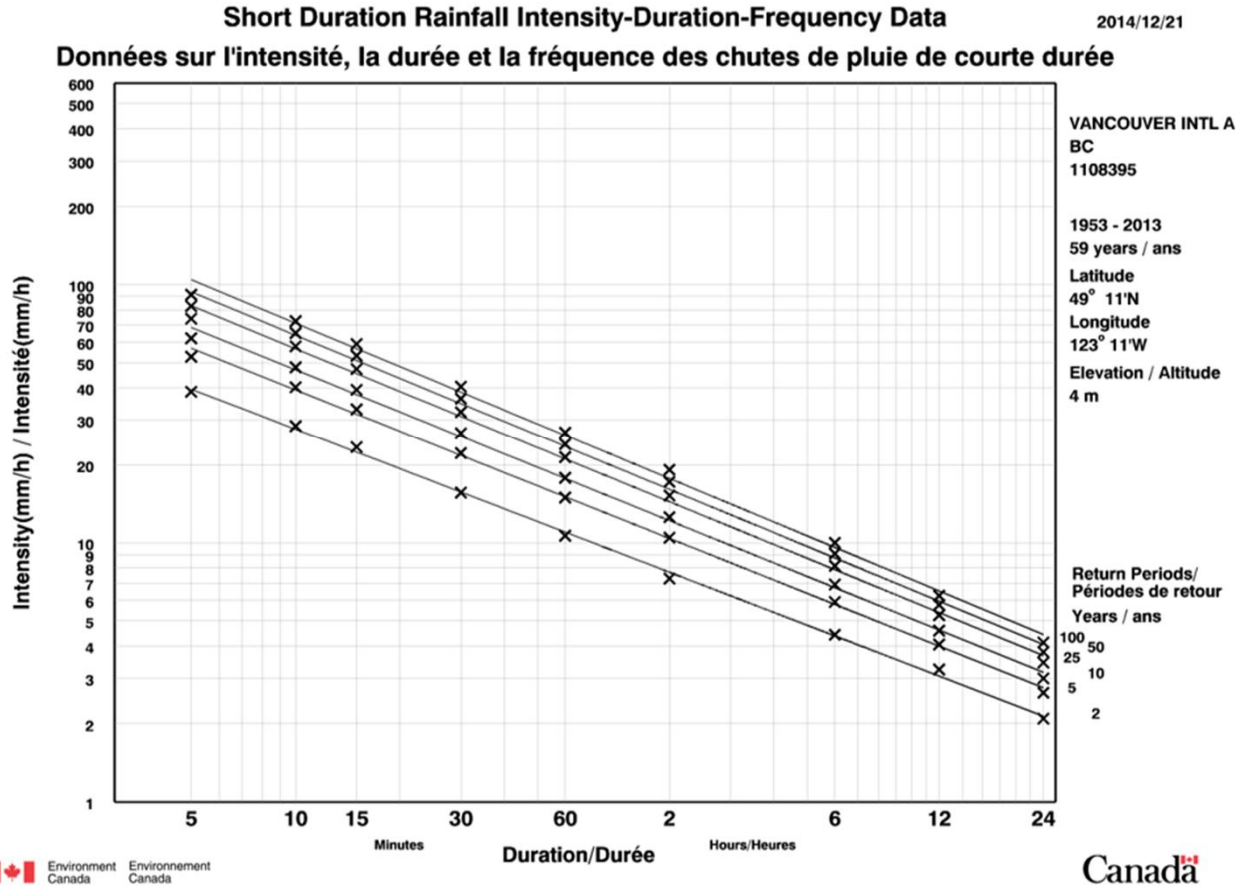
Values in 2015 $ CAN

The Hydrologic Model

Hydrology: Rainfall



Hydrology: Rainfall

- Different Terms for Probability
  - Return Period
  - Flood Frequency
  - Exceedance Probability

Hydrology: Rainfall

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100 Year Flood

The magnitude of flooding which has a
1% chance of occurrence in any year

Hydrology: Rainfall

- Different Terms for Probability
  - Return Period
  - Flood Frequency
  - Exceedance Probability

100 Year Flood

The magnitude of flooding which has a
1% chance of occurrence in any year

Key Point: Annual Probability

Hydrology: Runoff

- Definition:

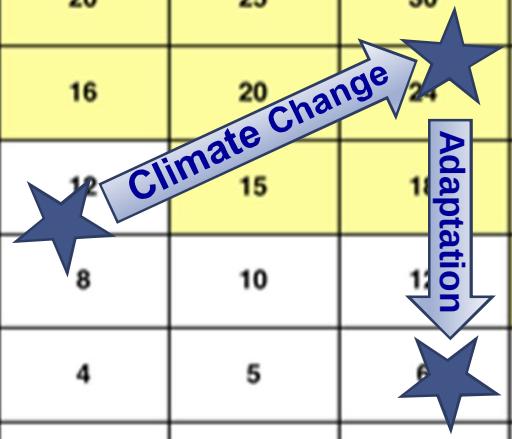
  "The volume of rainfall which flows off an area."

- Varies By Catchment Parameters
  - Area, Slope, Soil Type, Land Cover
- Varies By Rainfall

Hydrology: Runoff

Hydrology: Climate Change

7		Catastrophic 0.800	0	7	14	21	28	35	42	49
6	SEVERITY	Hazardous 0.400	0	6	12	18	24	30	36	42
5		Serious 0.200	0	5	10	15	20	25	30	35
4		Major 0.100	0	4	8	12	16	20	24	28
3		Moderate 0.050	0	3	6	9	12	15	18	21
2		Minor 0.025	0	2	4	6	8	10	12	14
1		Measurable 0.0125	0	1	2	3	4	5	6	7
0		No Effect	0	0	0	0	0	0	0	0
			negligible or not applicable	improbable 1:1 000 000 1:1 000	remote 1:100 000 1:500	occasional 1:10 000 1:200	moderate 1:1 000 1:100	probable 1:100 1:50	frequent 1:10	continuous 1:1 1:1
			PROBABILITY							
			0	1	2	3	4	5	6	7



Adapted from PIEVC Risk Table, Engineers Canada

The Hydraulic Model

The Hydraulic Model

The Traditional Approach

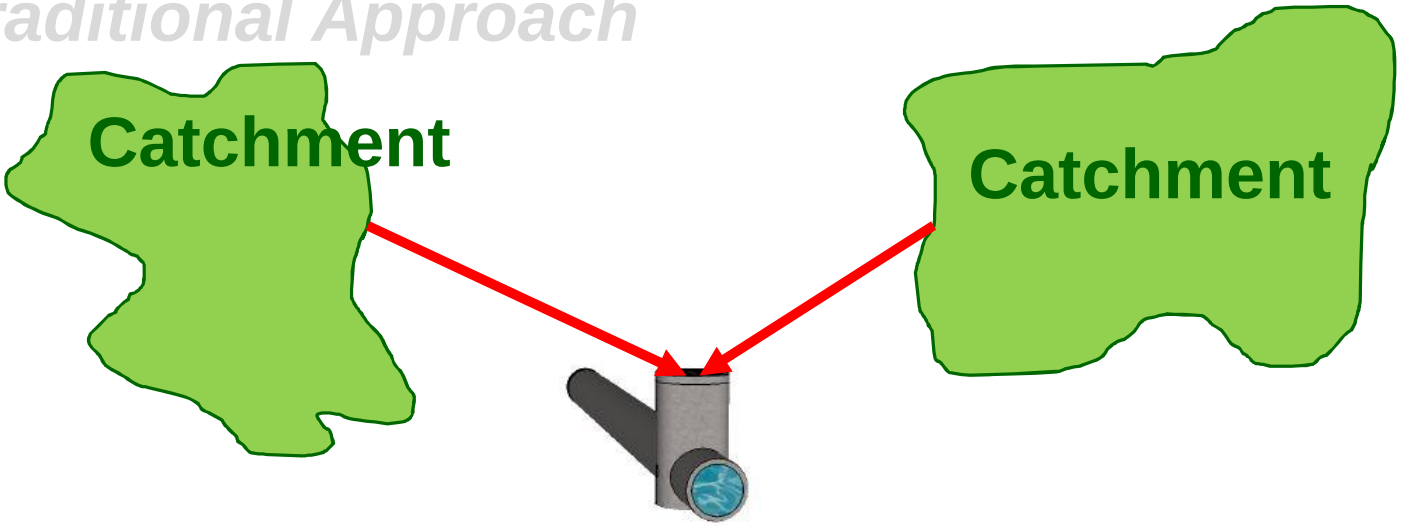
Pipe

MH

Minor System

The Hydraulic Model

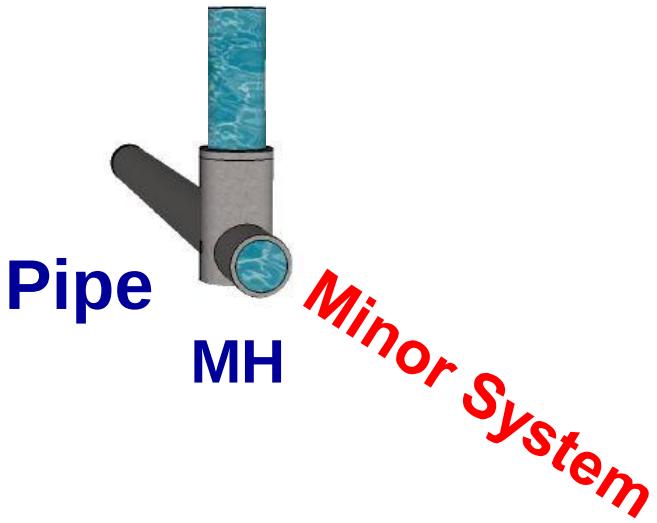
The Traditional Approach



- 100% collection efficiency
- No exchange of flow between minor and major system
- Excess flow stored at nodes
- No transference of flow to next d/s node

The Hydraulic Model

The Traditional Approach

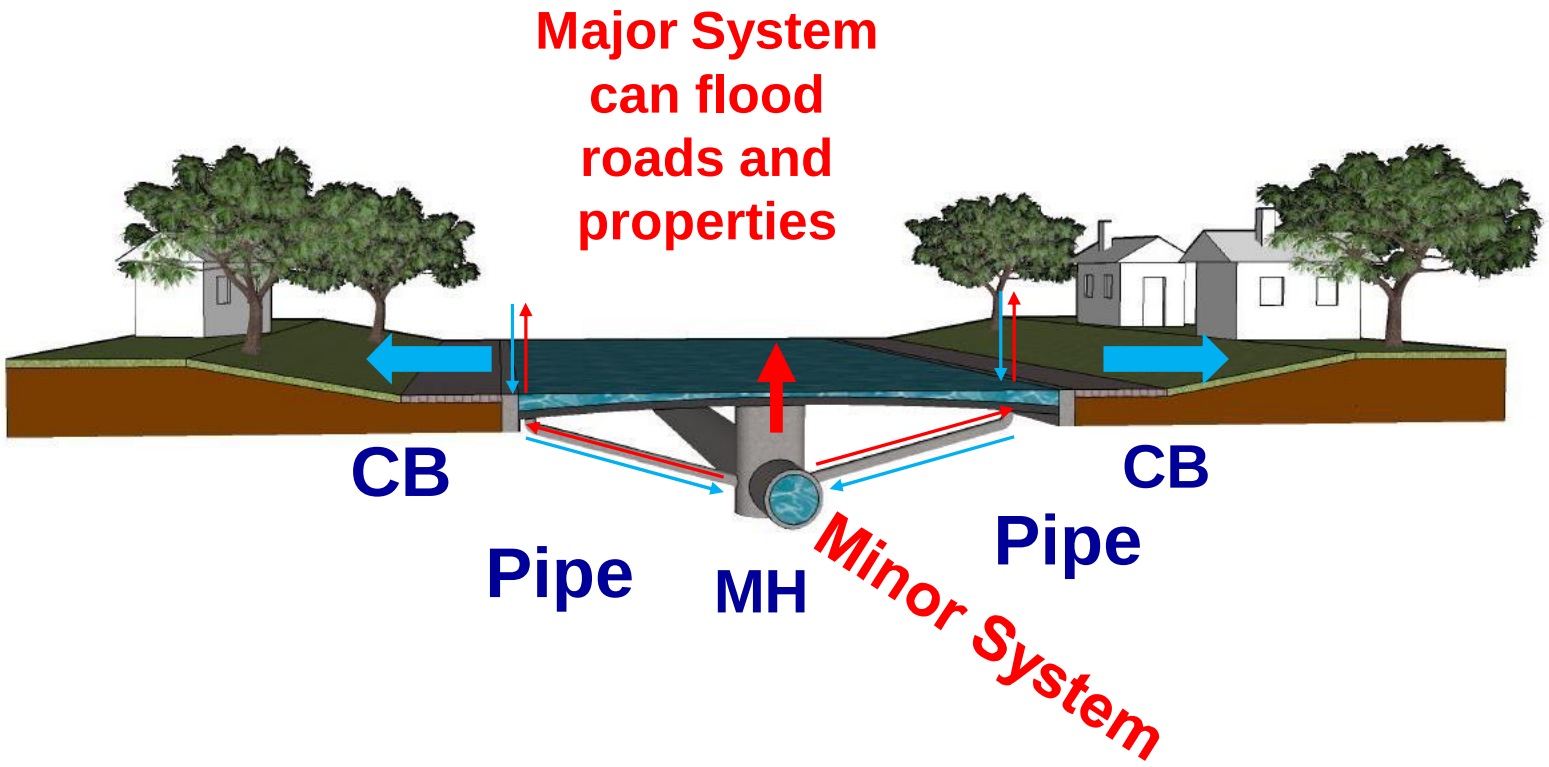



5-year (2013)


100-year (2080)

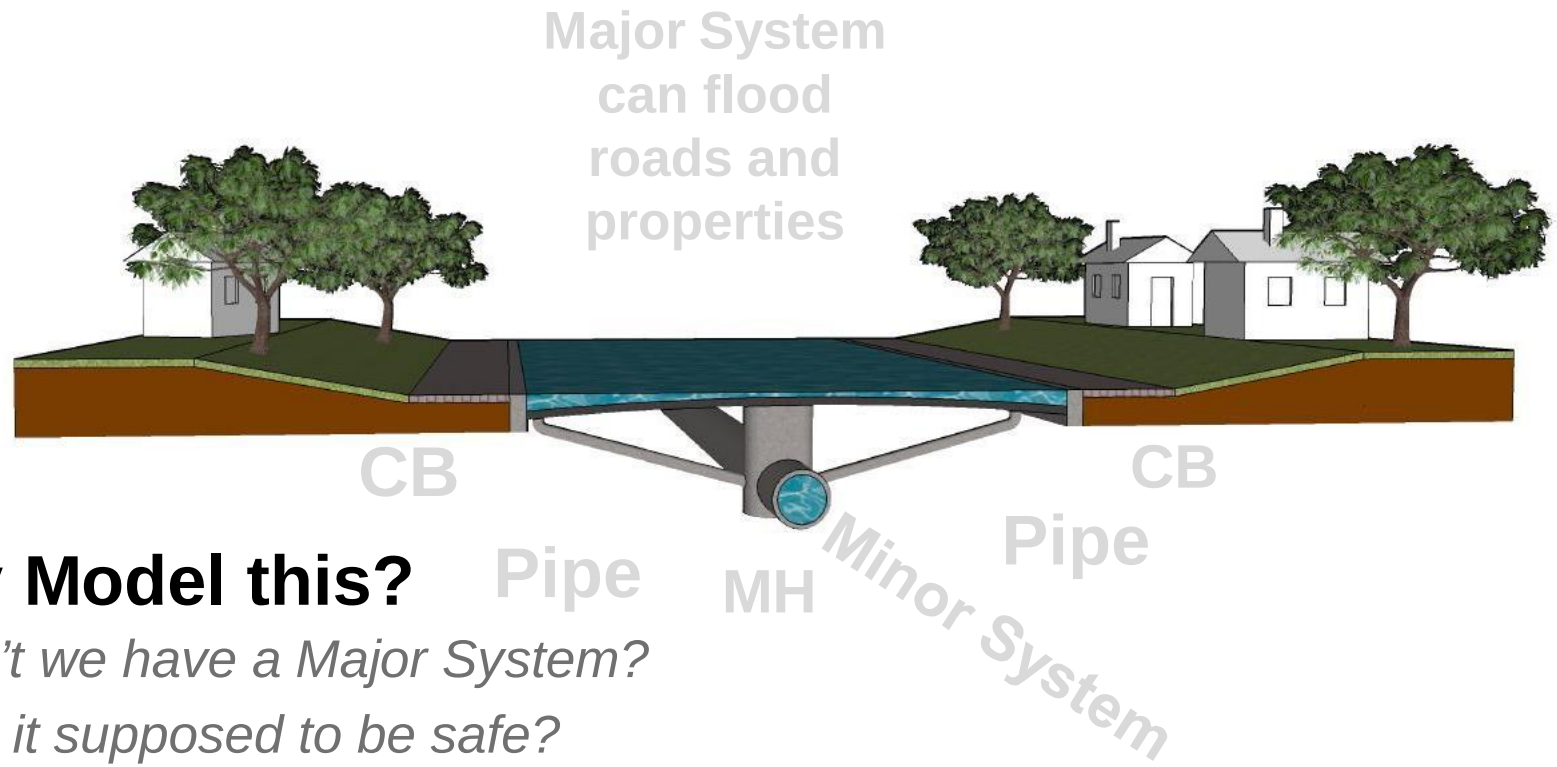
The Hydraulic Model

*The **New** Approach*



The Hydraulic Model

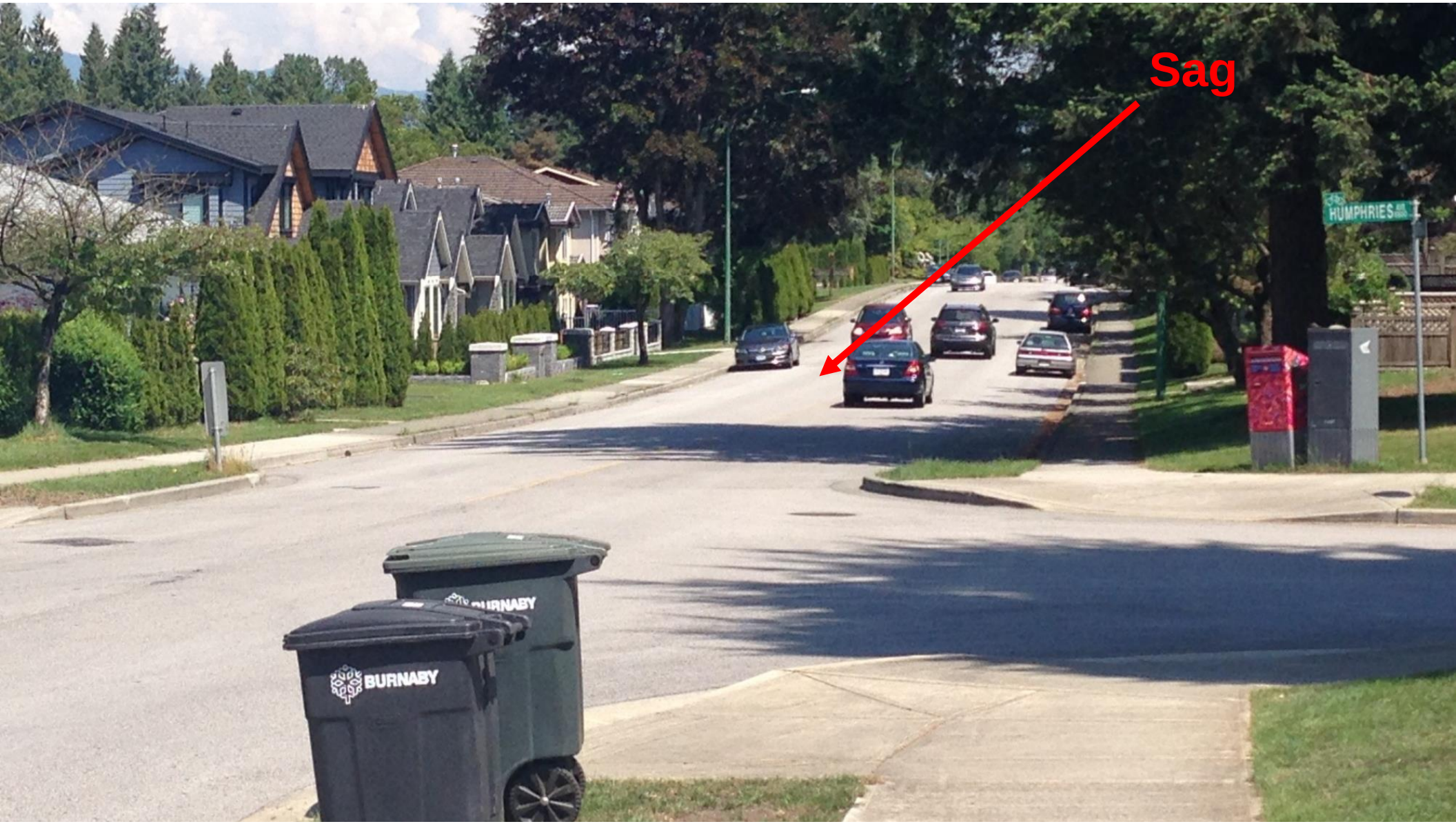
*The **New** Approach*



Why Model this?

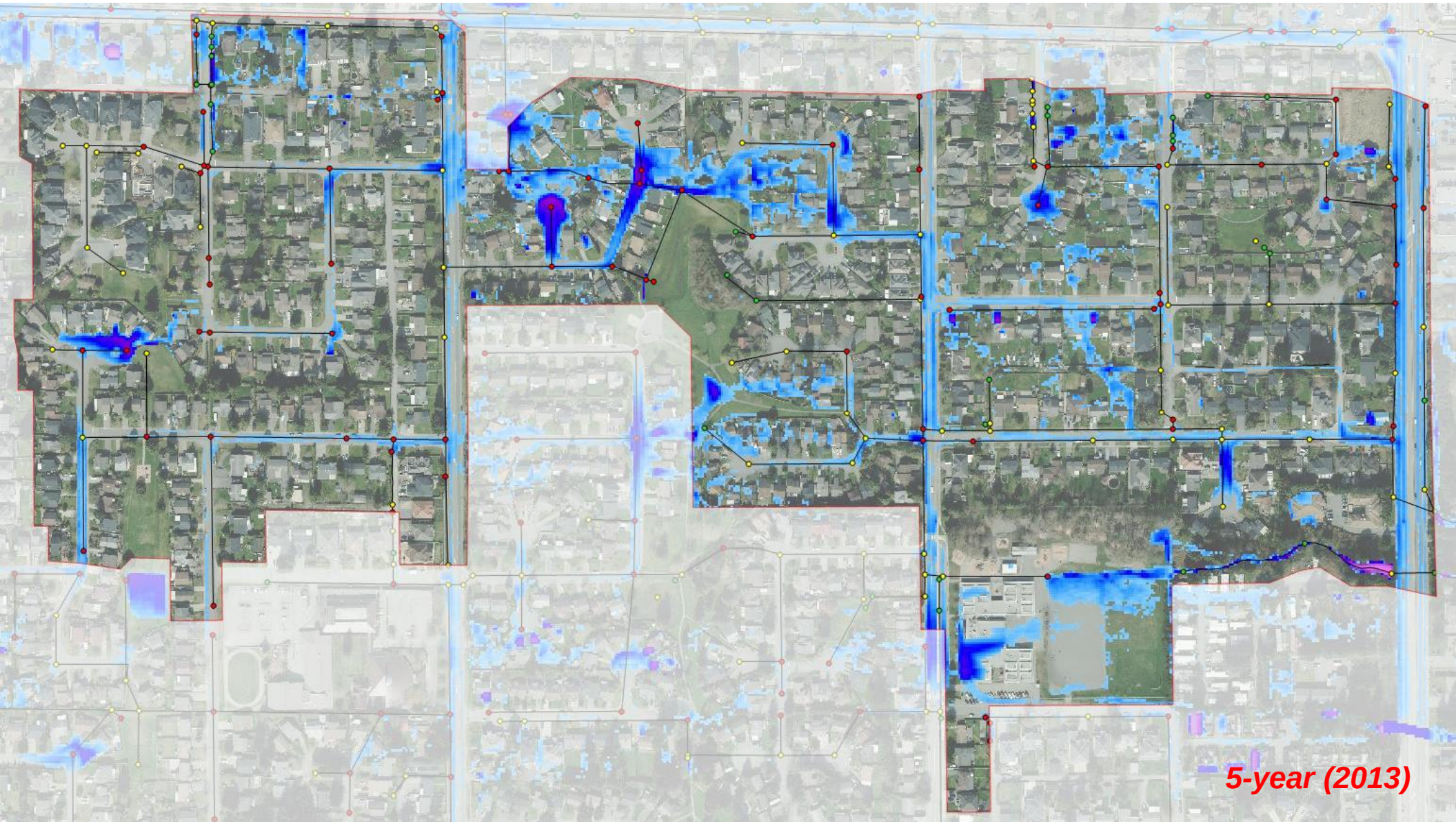
- *Don't we have a Major System?*
- *Isn't it supposed to be safe?*

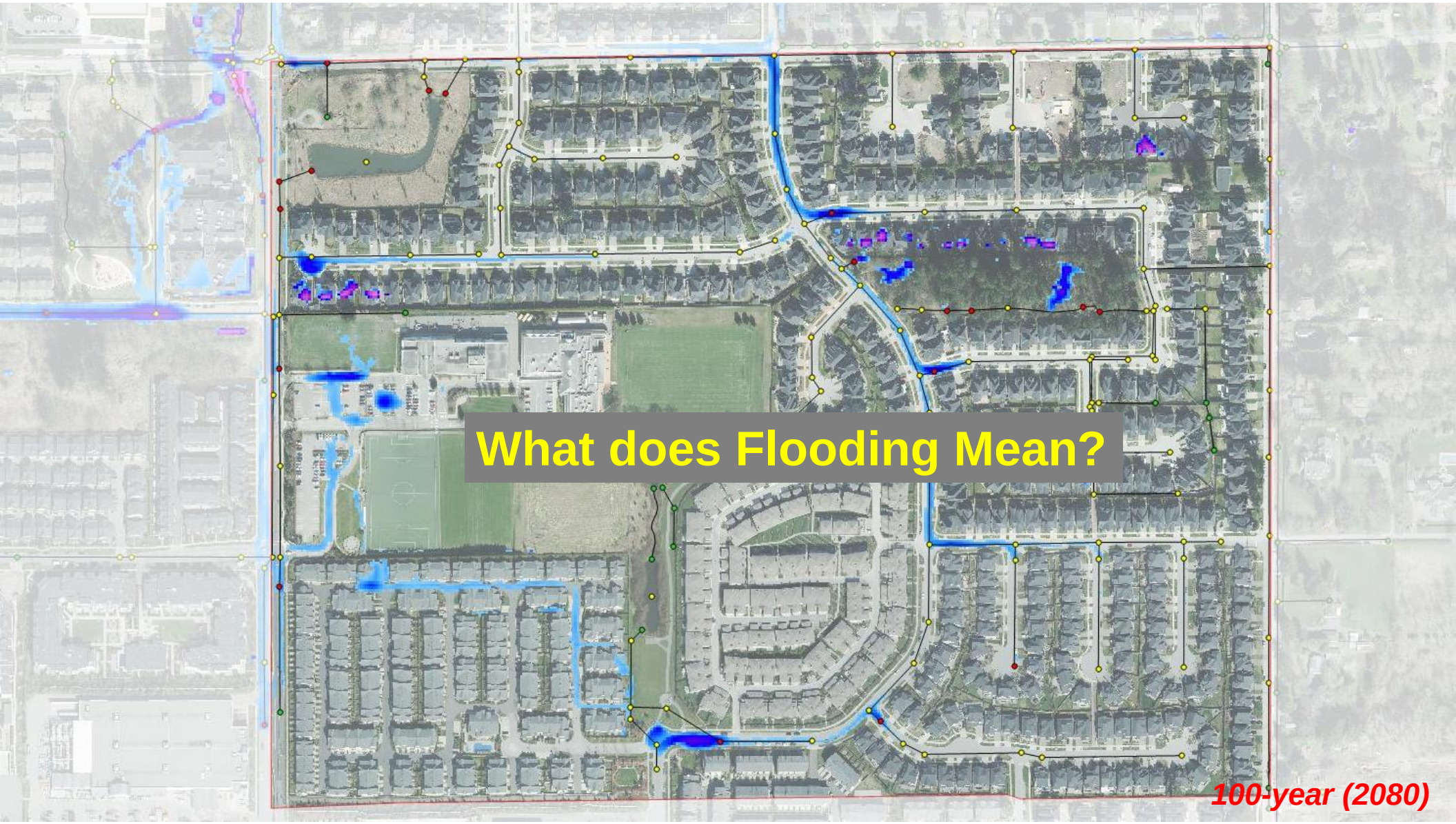

Sag
Imperial Street between
Walker and Canada Way


Sag
HUMPHRIES
BURNABY
BURNABY


7483
7489
The Sag


Sag


5-year (2013)

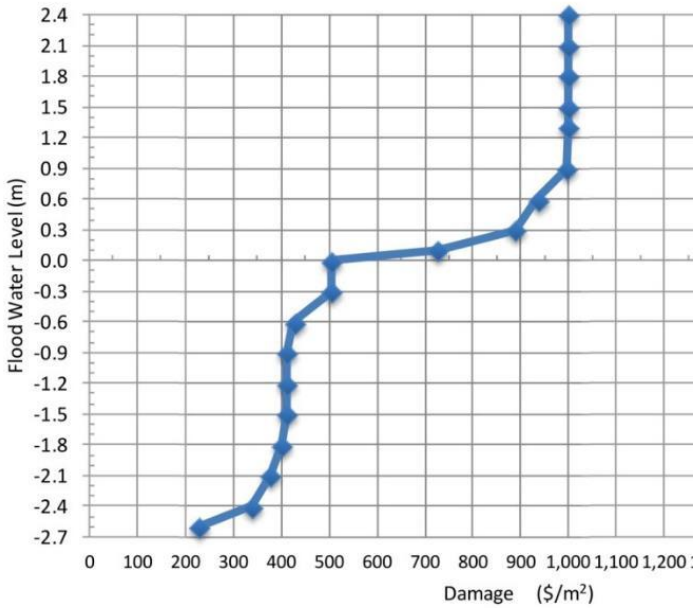

What does Flooding Mean?
100-year (2080)

The Flood Damage Calculations

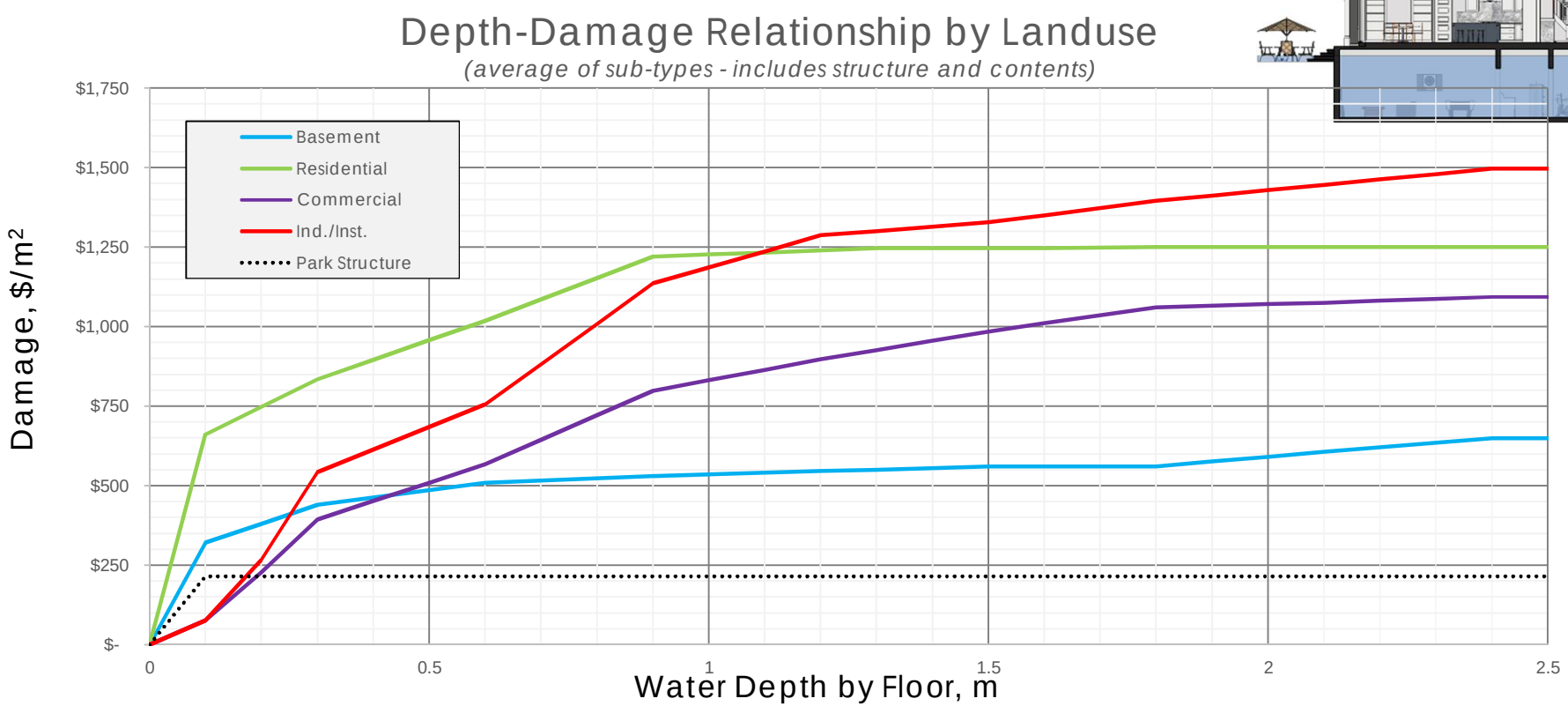
The Flood Damage Calculations

Overview…

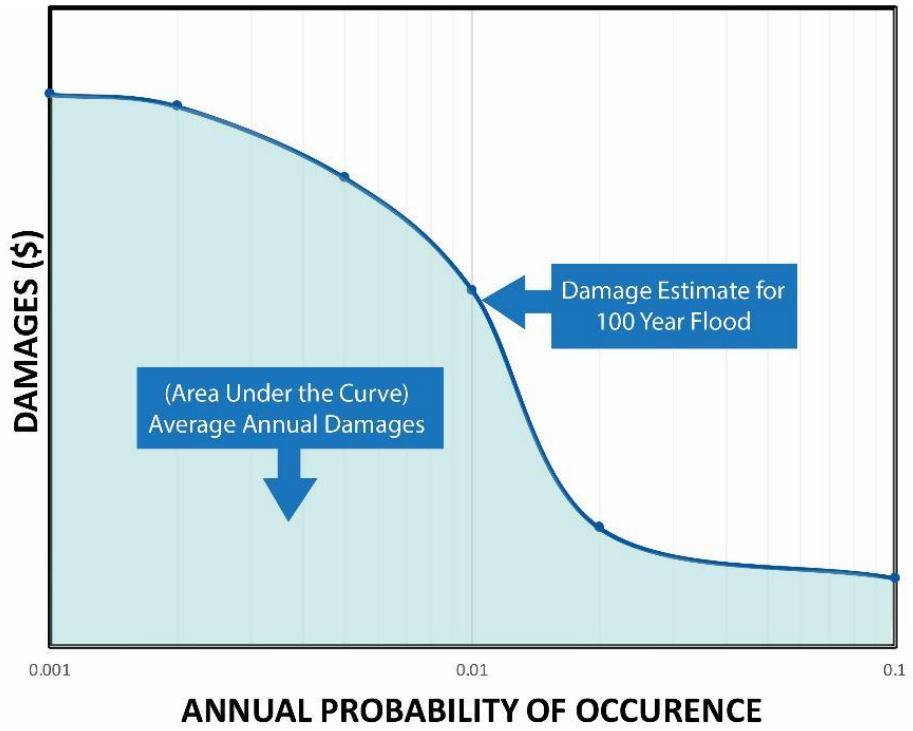
- Depth-Damage Curves



Depth Damage Curves



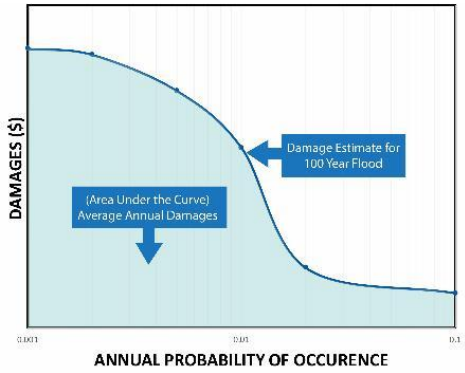
Average Annual Risk



Average Annual Risk

$$Total\ Damage = \frac{Y}{2}\sum_{i=2}^{n}[D_i + D_{i-1}] \times \left[\frac{1}{R_{i-1}} - \frac{1}{R_i}\right]$$

- Where:
  - n = The total number of return periods
  - D = Damage at a given return period ($)
  - R = Return Period (i.e. 50, 100, etc.)
  - Y = Record of Interest (years)



The Model Results

The Model Results

Analysis

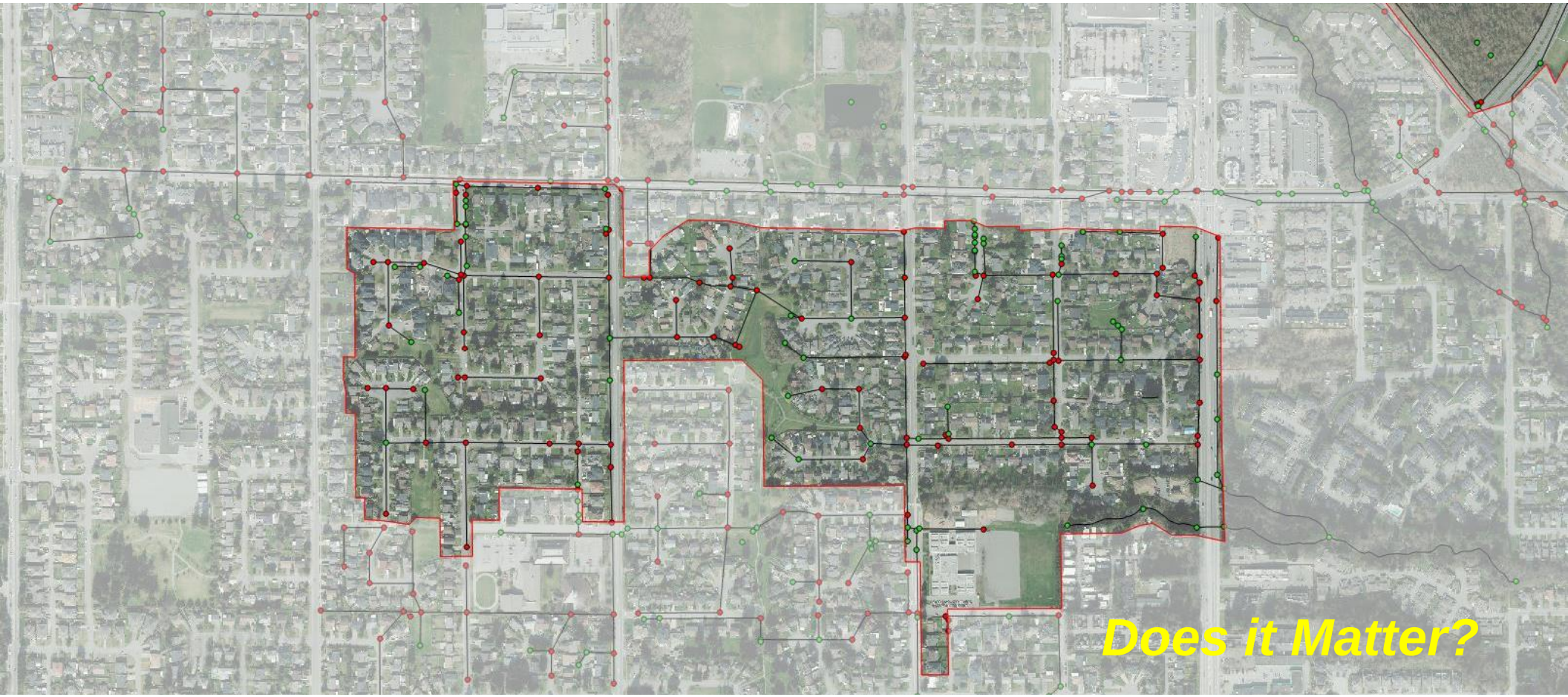
- Hydraulic Analysis to estimate flood extents
- Flood Damage Calculations

Time Horizon	5-year (20% AEP)	100-year (1% AEP)
2013	P	P
2030	P	P
2050	P	P
2080	P	P

The Model Results

Area 1 – Older Residential Area

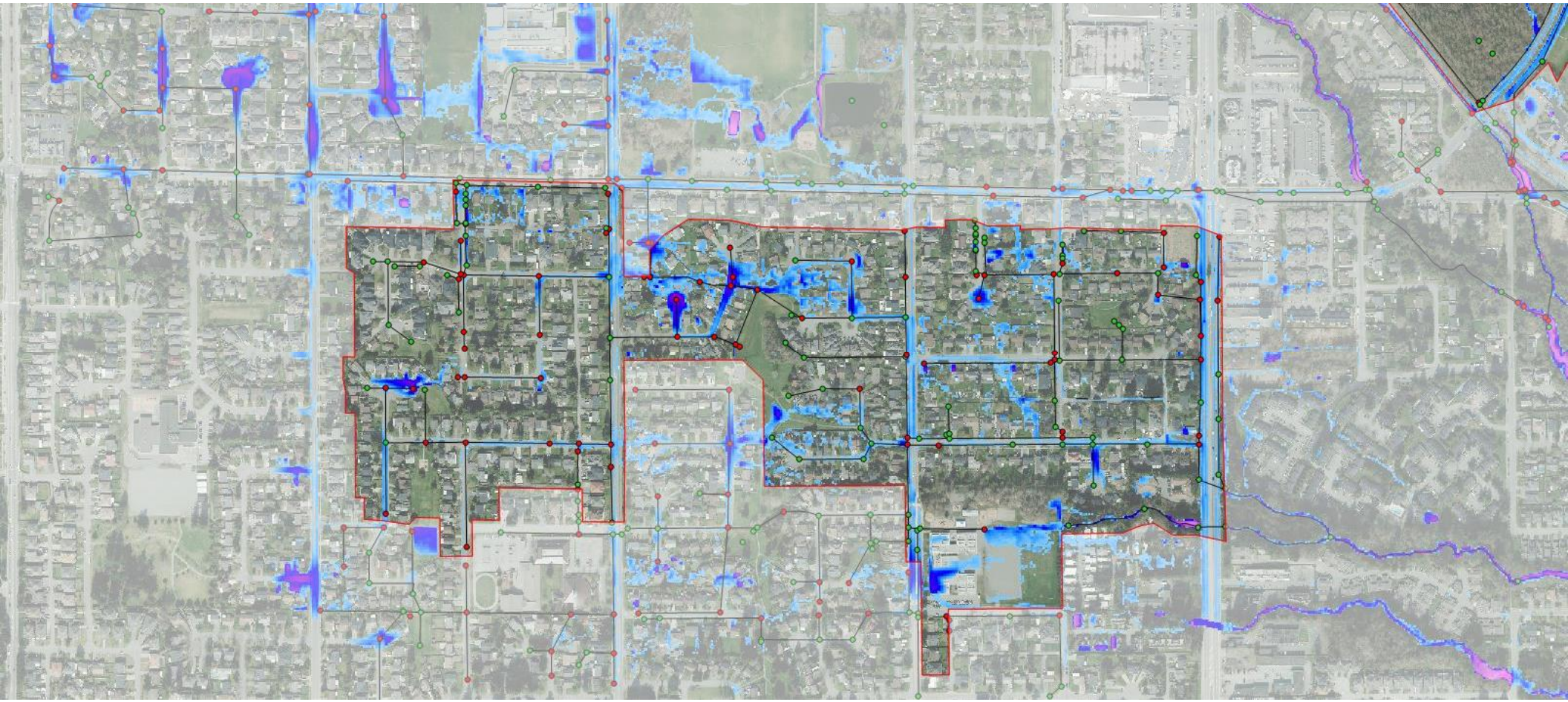
5-year (2013)



The Model Results

Area 1 – Older Residential Area

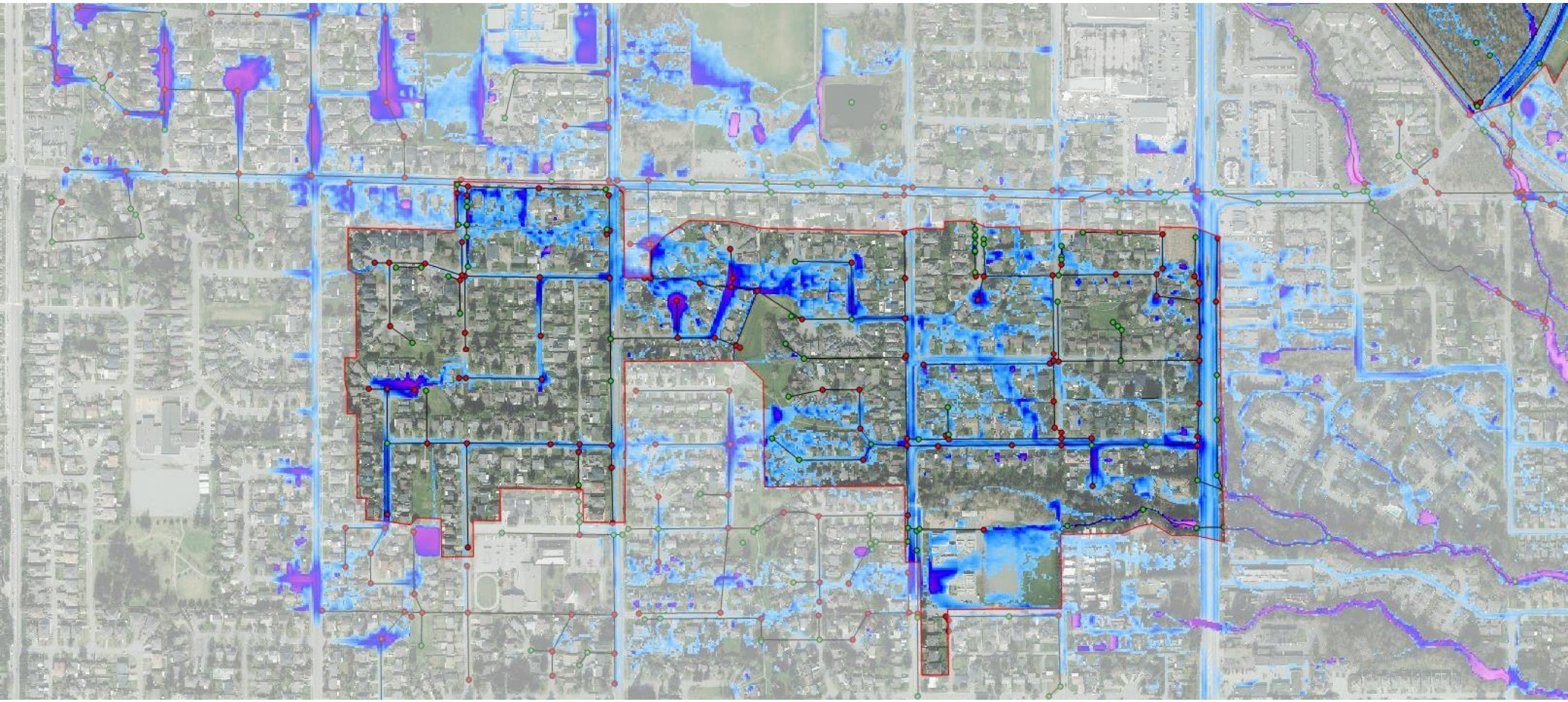
5-year (2013)



The Model Results

Area 1 – Older Residential Area

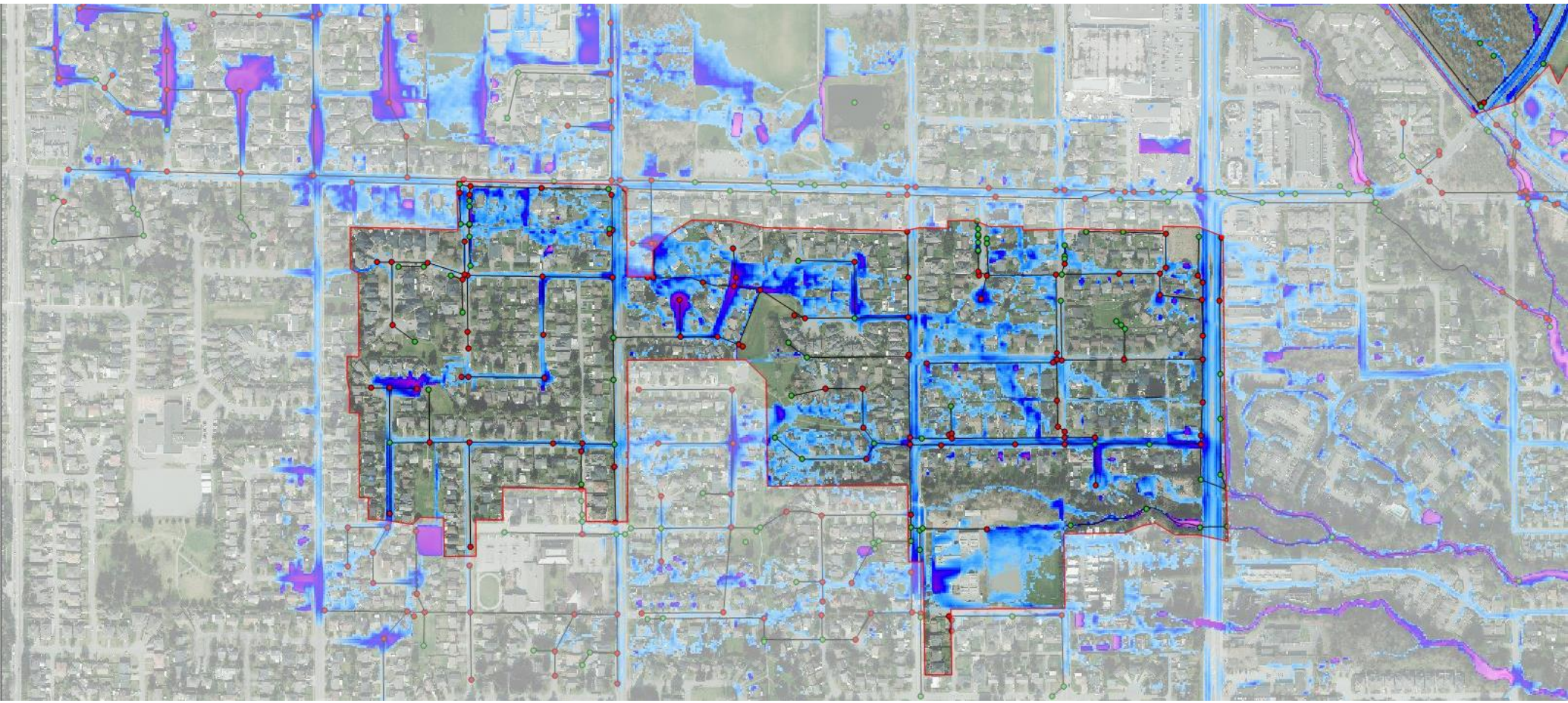
5-year (2080)



The Model Results

Area 1 – Older Residential Area

100-year (2080)



The Model Results

Area 2 – Newer Residential Area

5-year (2013)

The Model Results

Area 2 – Newer Residential Area

5-year (2080)

The Model Results

Area 2 – Newer Residential Area

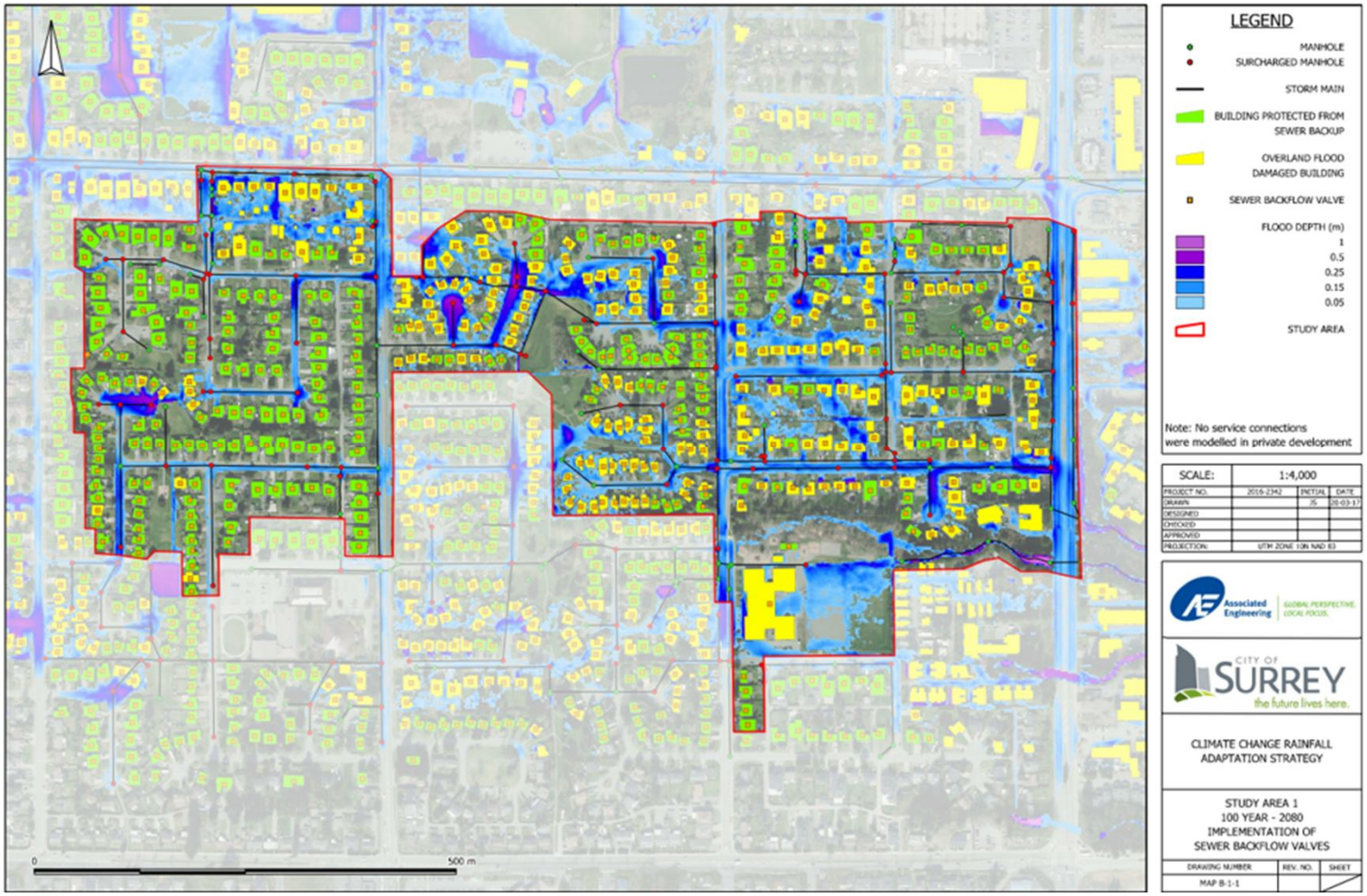
100-year (2080)

Mitigation Options

Available Adaptation Options

- Backflow Preventers
- Lot-Level Storage
- Sump Pumps
- Basement Window Well Protection
- Bylaw Changes to Reduce Flood Vulnerability
- Modify Overland Flow Paths
- Lot Grading Strategy
- Purchase & Abandon Property
- Minimum Building Elevation
- Upgrade Pipe Conveyance
- Pipe Storage
- Peak Flow Diversion
- New Community Ponds
- Retrofit Existing Ponds

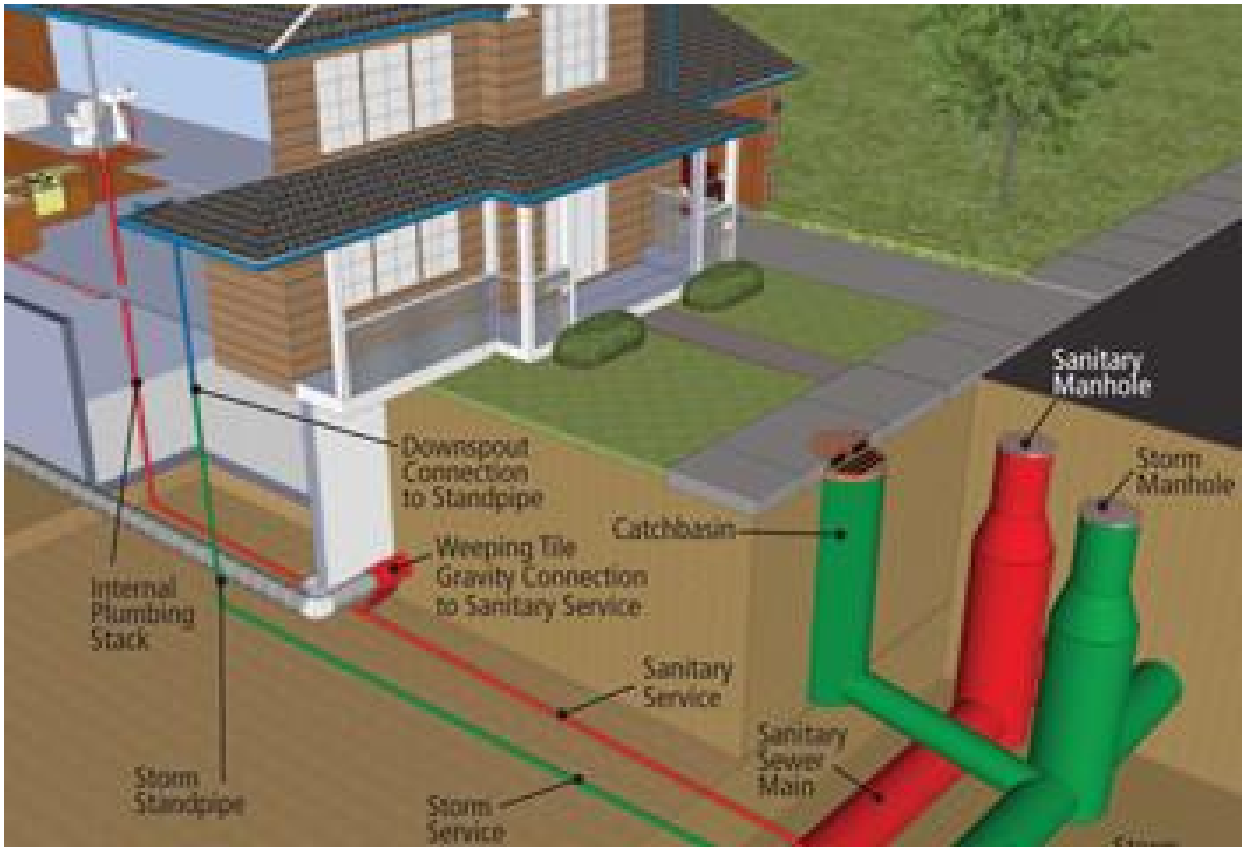
Sewer Backflow Preventers



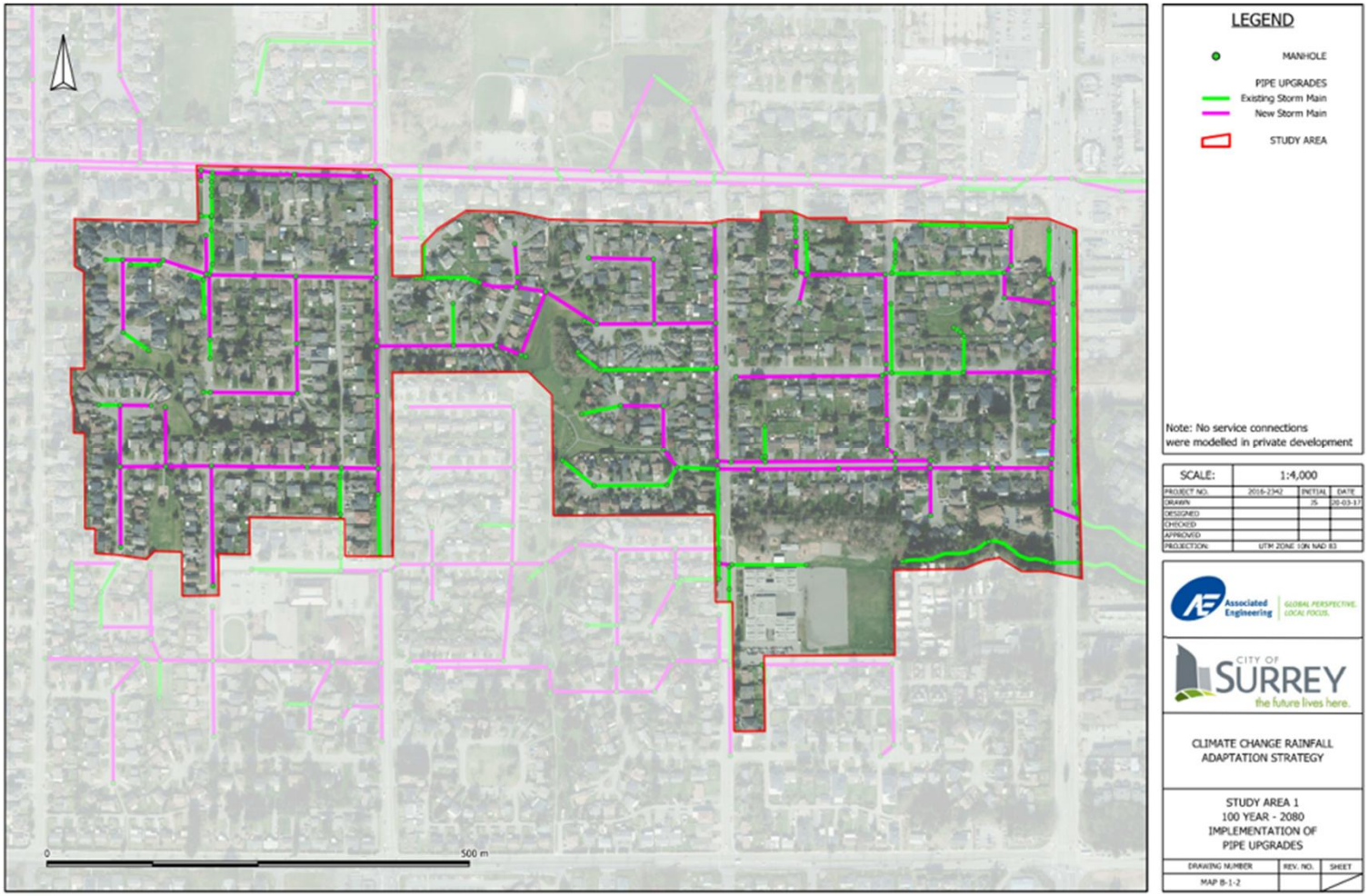
Mitigation Options

Sewer Backup Valves

- Benefit–Cost Ratio: 200 to 400
- Easy Implementation



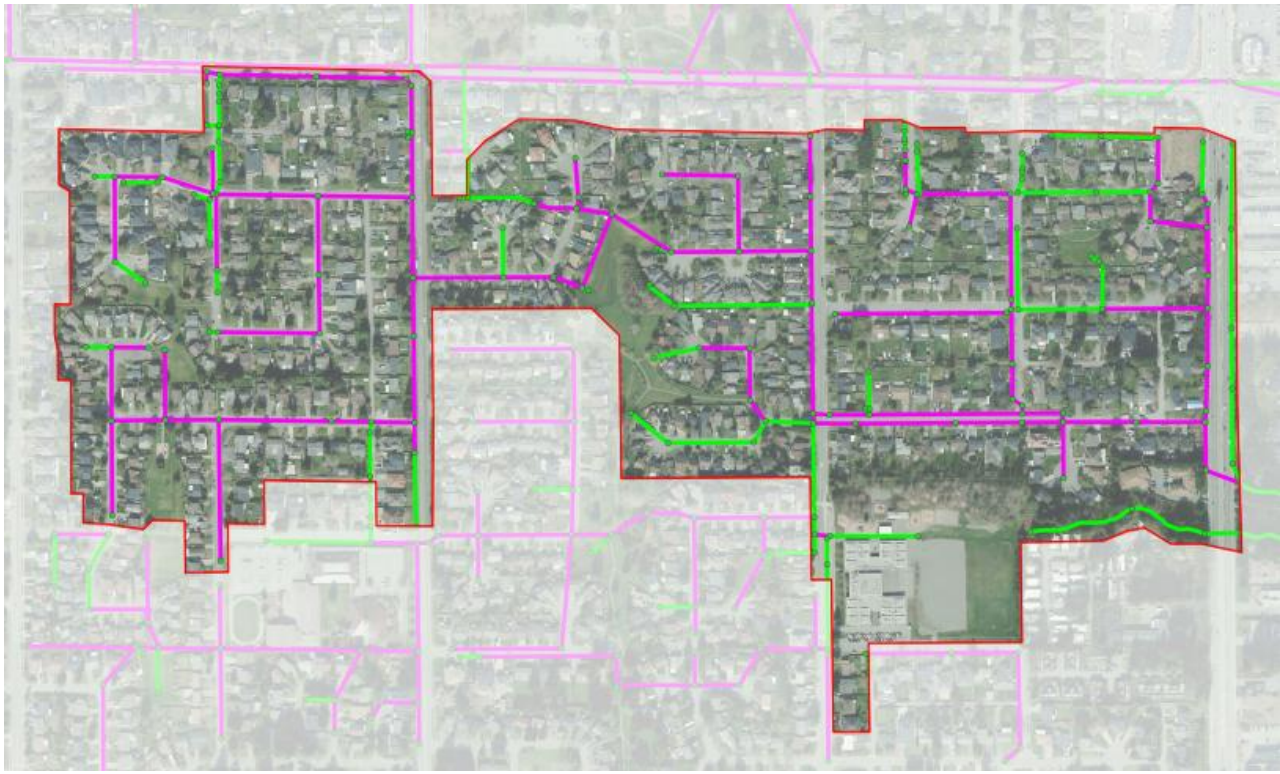
Upgrade Pipe Conveyance



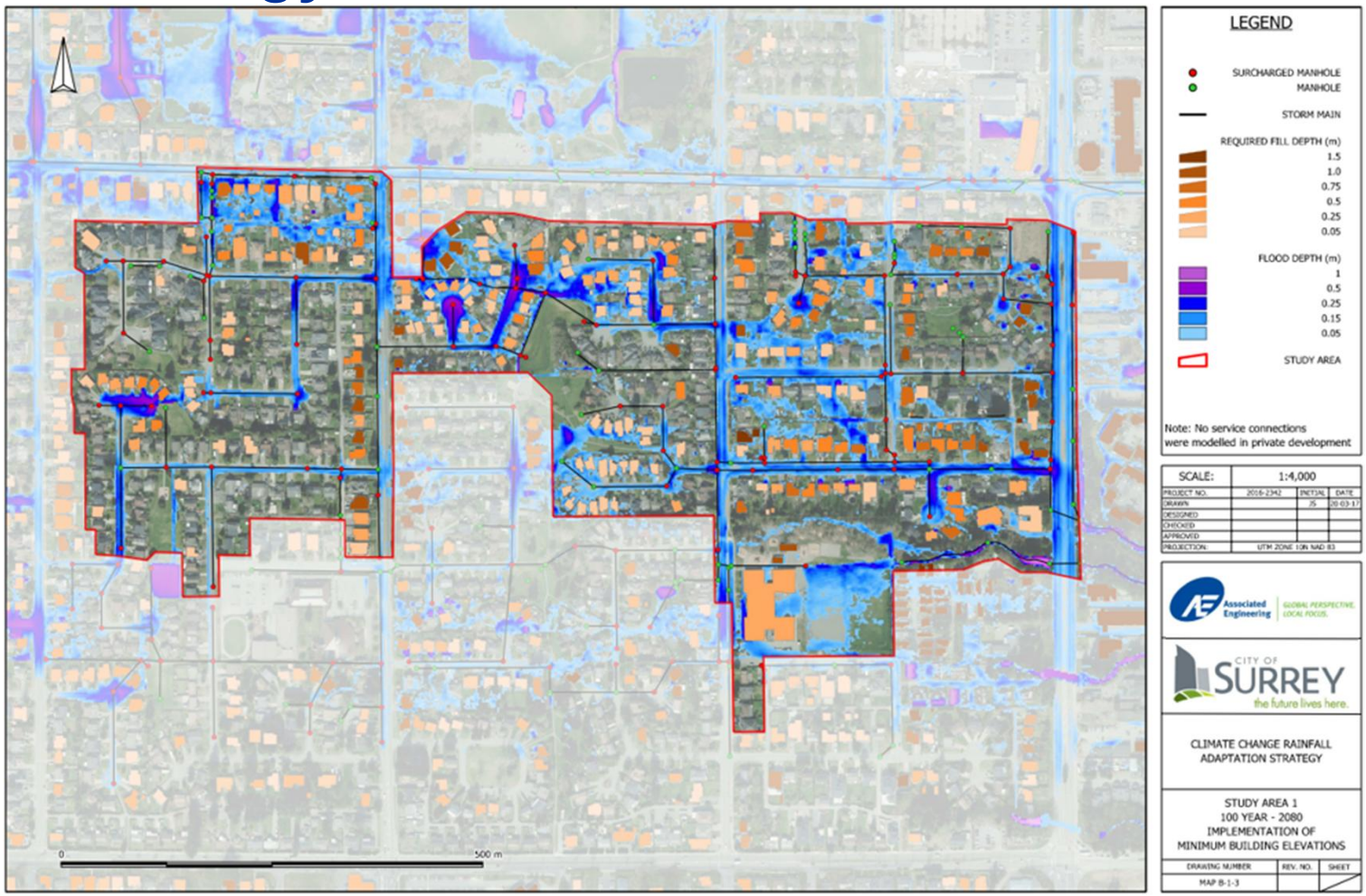
Mitigation Options

Pipe Upgrades

- Sized for 5-year 2080
- Benefit-Cost Ratio = 15 to 50



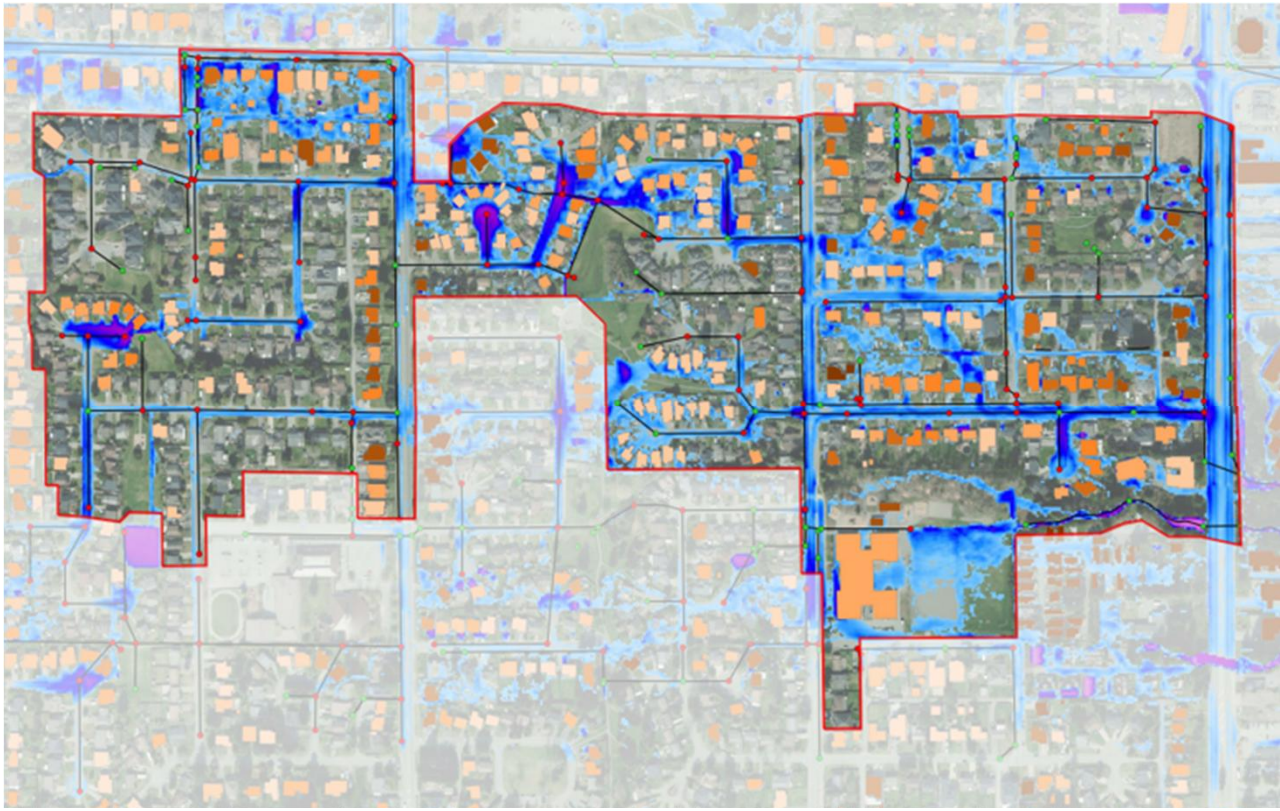
MBE Strategy



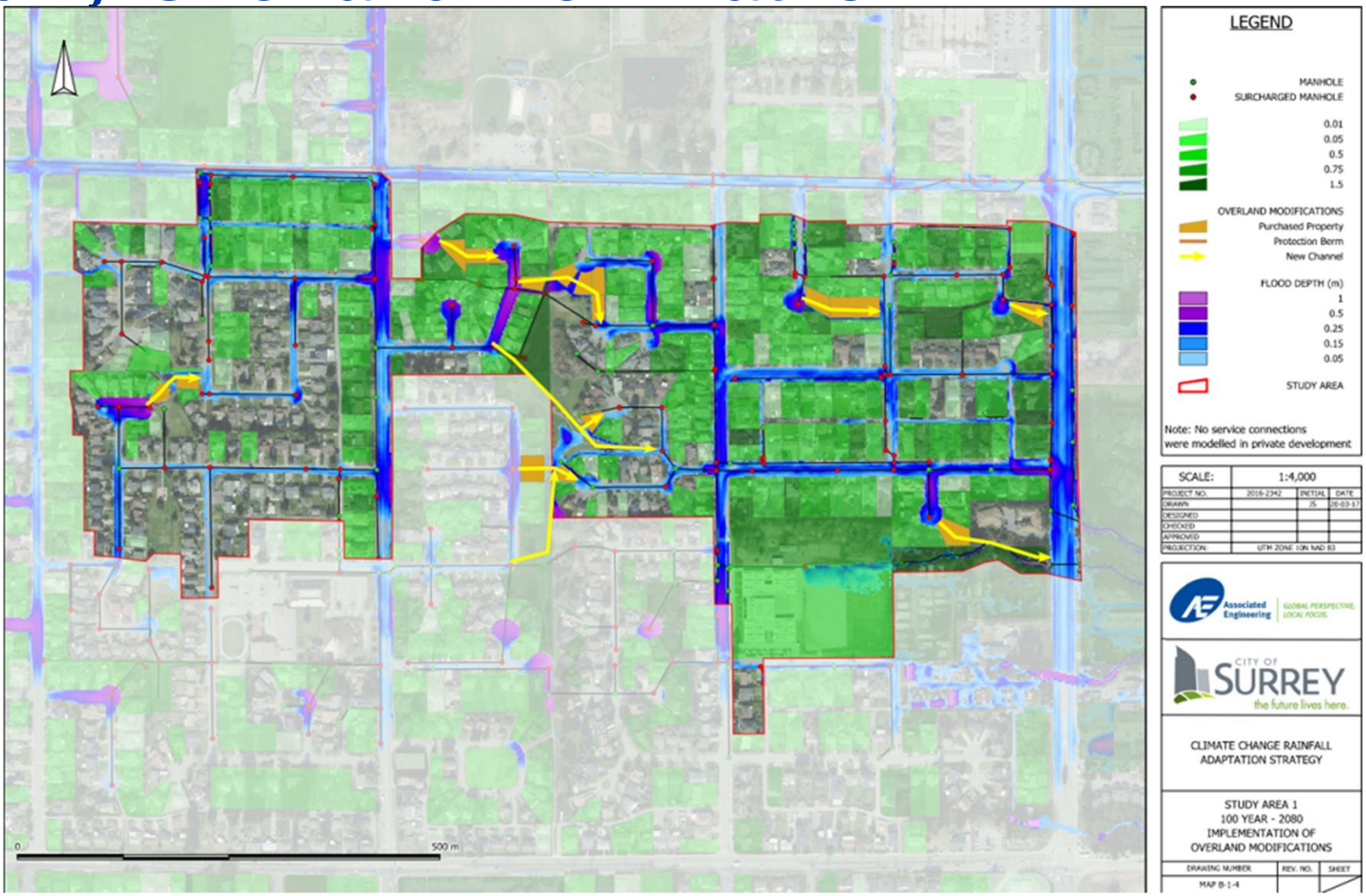
Mitigation Options

Minimum Building Elevation

- Sized for 100-year 2080
- Benefit-Cost Ratio = 15 to 80
- Long Implementation



Modify Overland Flow Paths



Mitigation Options

Modify Overland Flow Paths

- Sized for 100-year 2080
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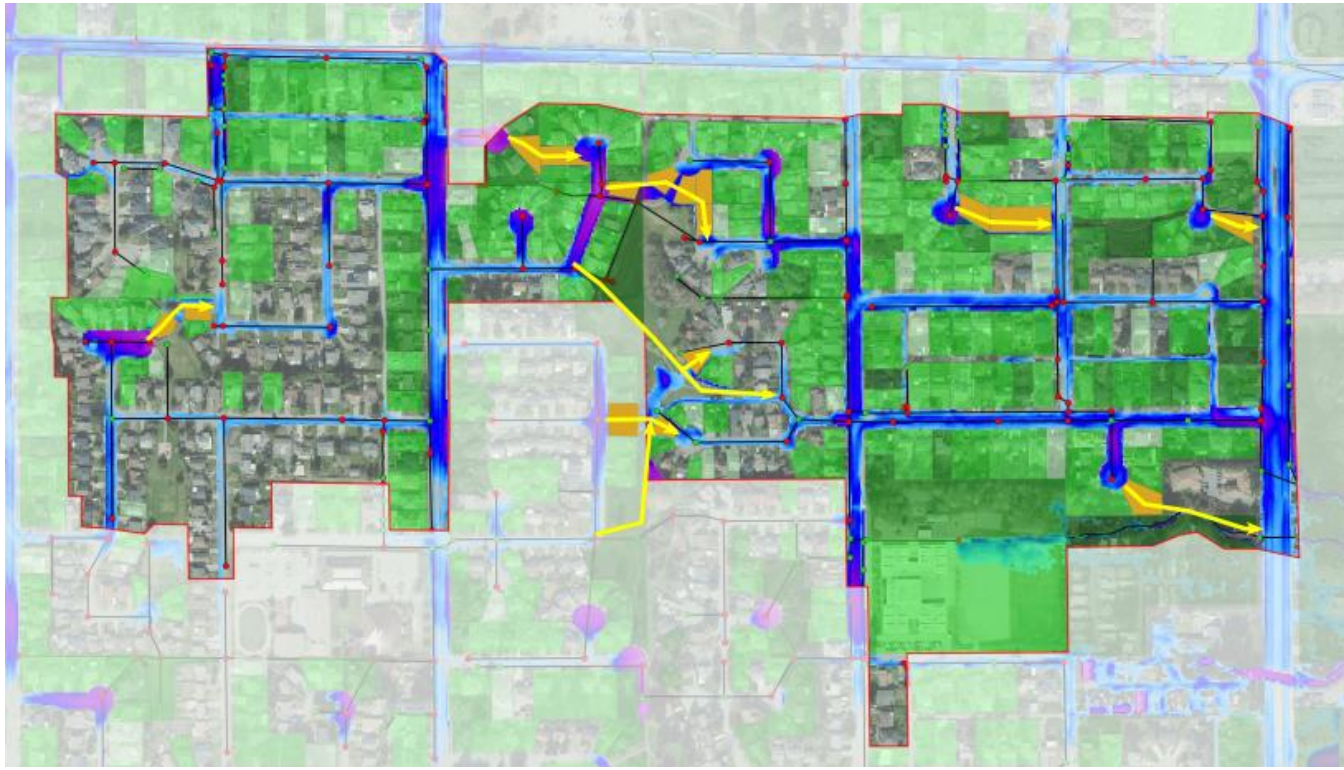

Insurance & DFA Assistance

Que

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Emergency ManagementBC

Disaster Financial Assistance (DFA) and

RESIDENTIAL FLOOD INSURANCE

The purpose of DFA is to help individuals and small business owners recover from uninsurable disasters. The DFA program operates under the *Emergency Program Act* and the ensuing Compensation and Disaster Financial Assistance Regulation and is required to provide compensation in compliance with this legislation. DFA eligibility criteria, as defined in the Act and the Regulation, have been applied consistently and fairly throughout the province since 1995.

Section 8 of the Regulation states that "*eligible costs does not include costs or expenses … for which insurance was reasonably and readily available*".

Until recently overland flood insurance was only available for commercial buildings.

It is expected that in the next two years this insurance will be reasonably and readily available for single family residential homes across all of BC. The phrase 'readily available' means that a person could obtain this insurance from a local agent or broker. 'Reasonably available' should not be confused with affordable. What a person can afford is subjective and specific to that person. What is important is that the price of the insurance was reasonable considering the risk.

EMBC is closely monitoring the availability of overland flood insurance in BC and will continue to deliver DFA in accordance with existing legislation. **If a flooding disaster occurs and DFA is authorized for a disaster event, an applicant who could reasonably and readily have purchased overland flood insurance would NOT be eligible for DFA.**

Over the next several years as additional insurance options roll out, EMBC will apply discretion in how it determines eligibility. For example, a homeowner or tenant would not be expected to amend their existing policy as soon as overland flood insurance becomes available. But, DFA may be denied if overland flood insurance was available on renewal and they chose not to purchase it.

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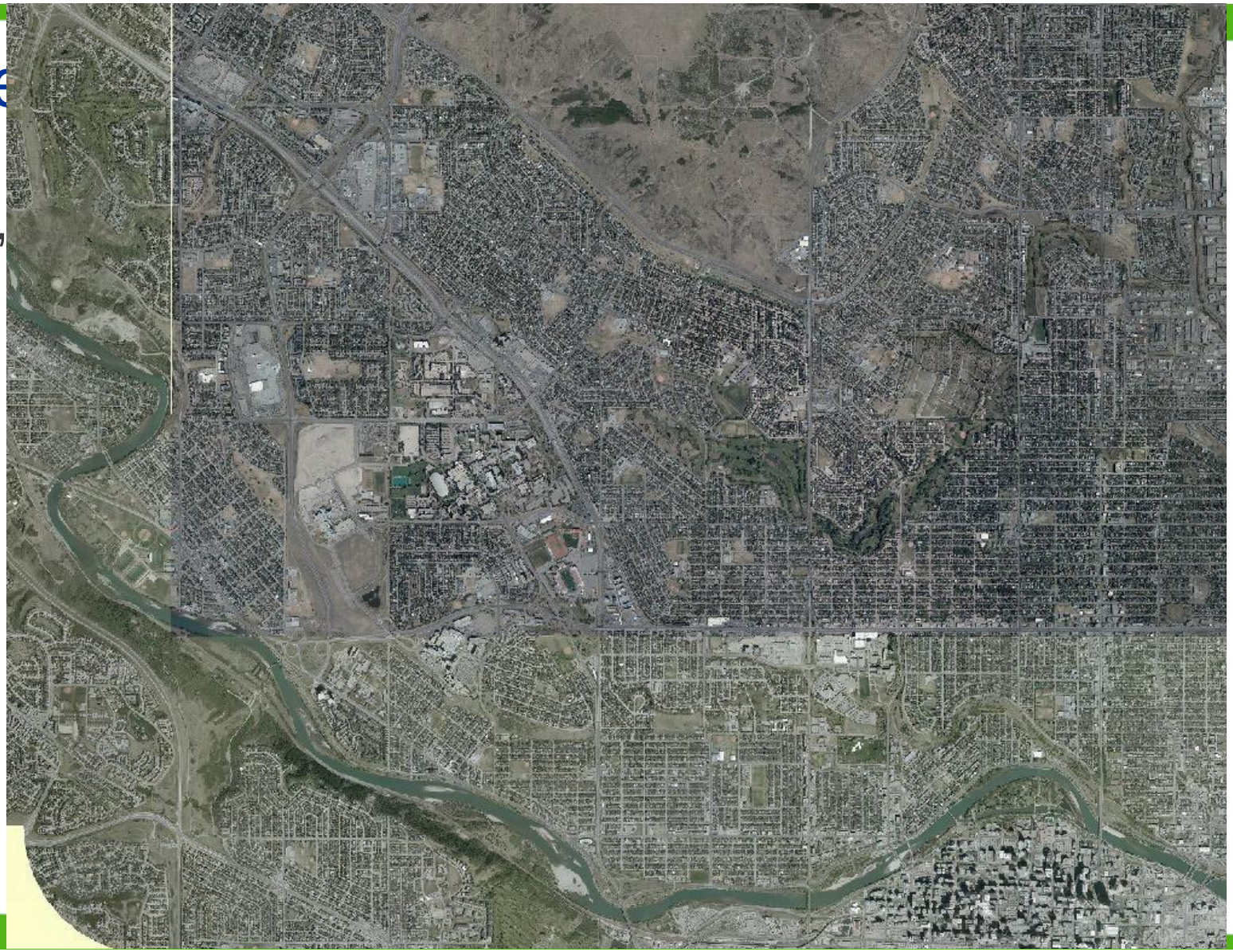

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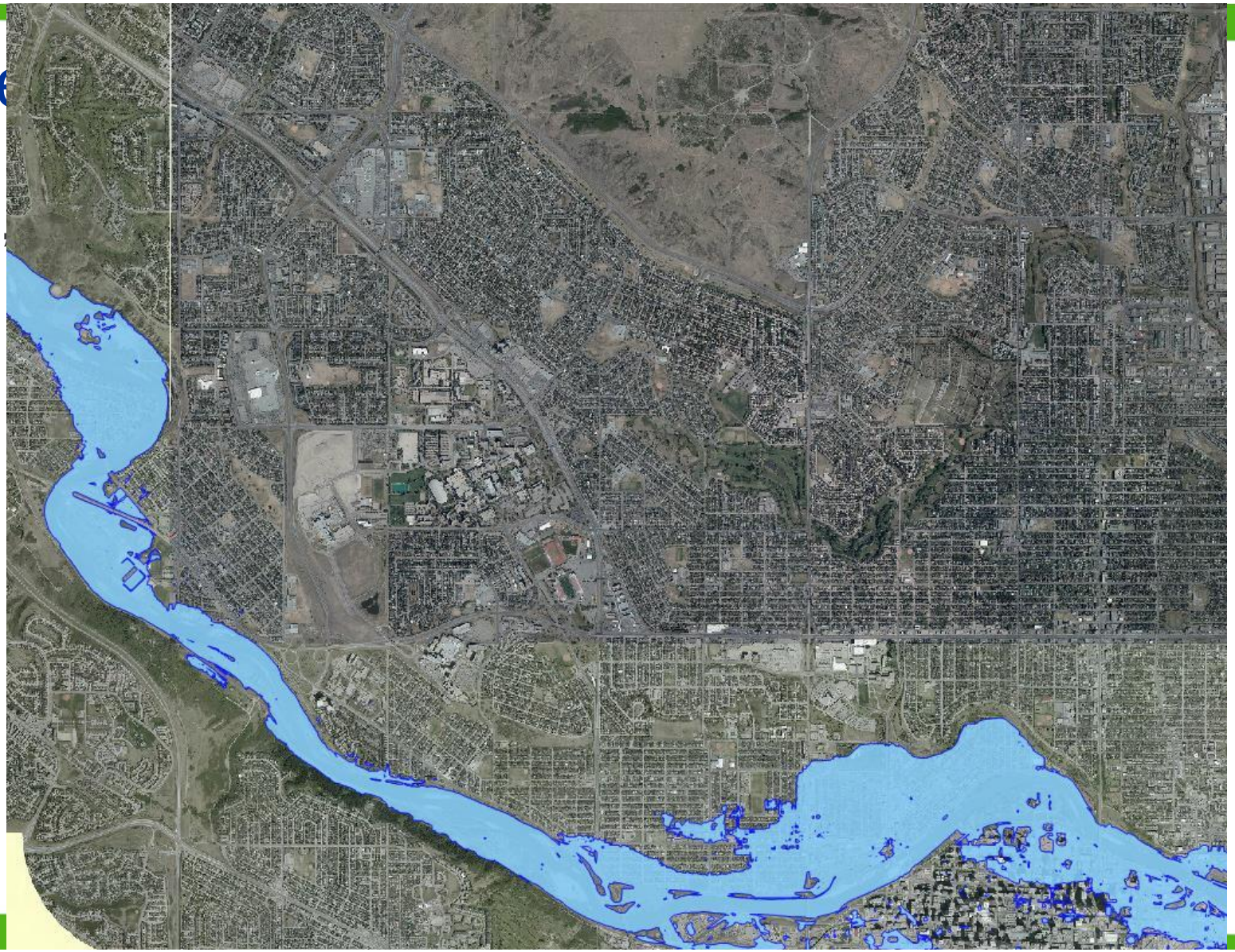

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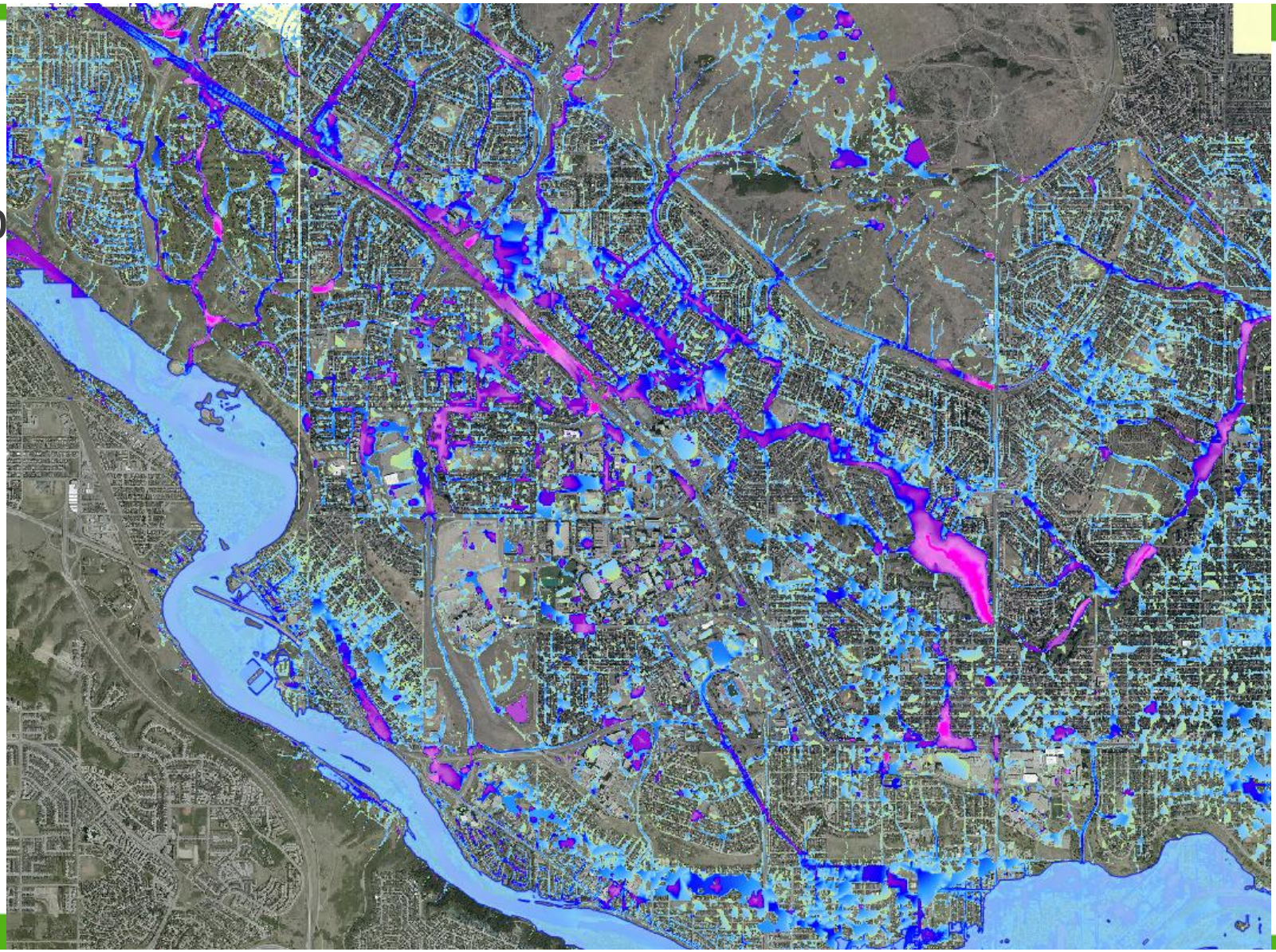
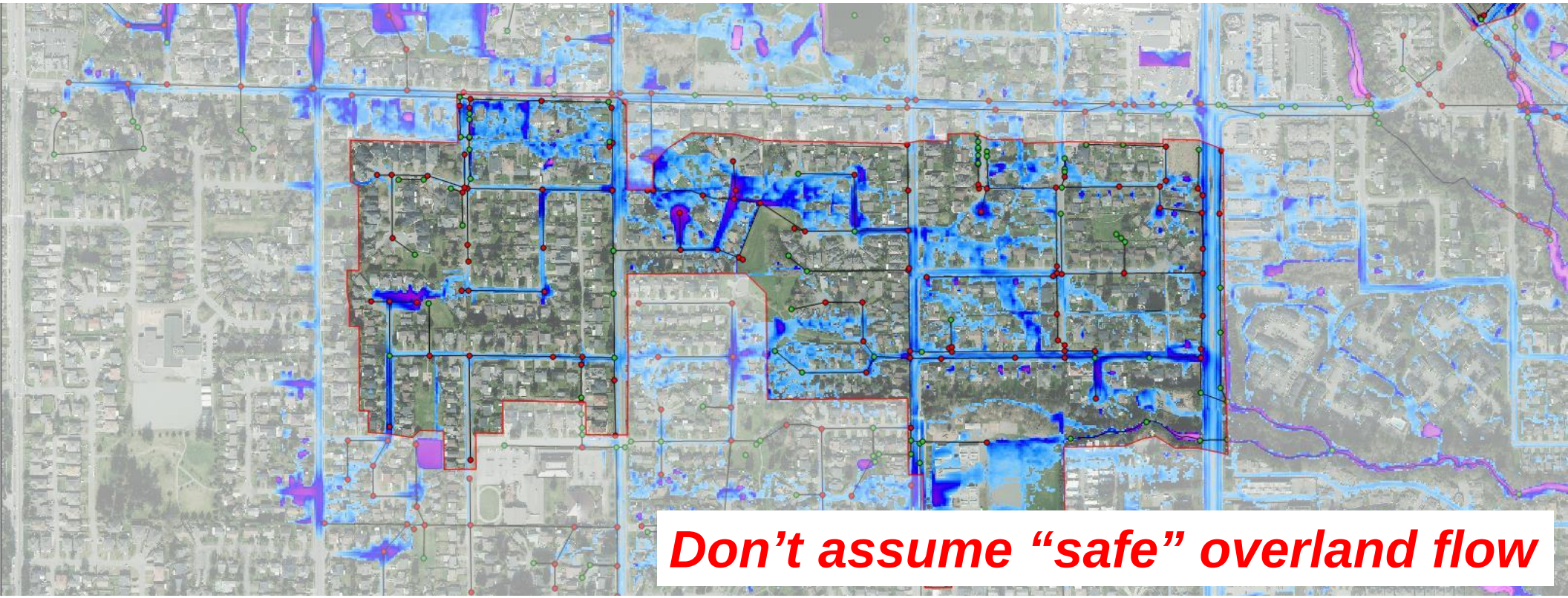


Summary

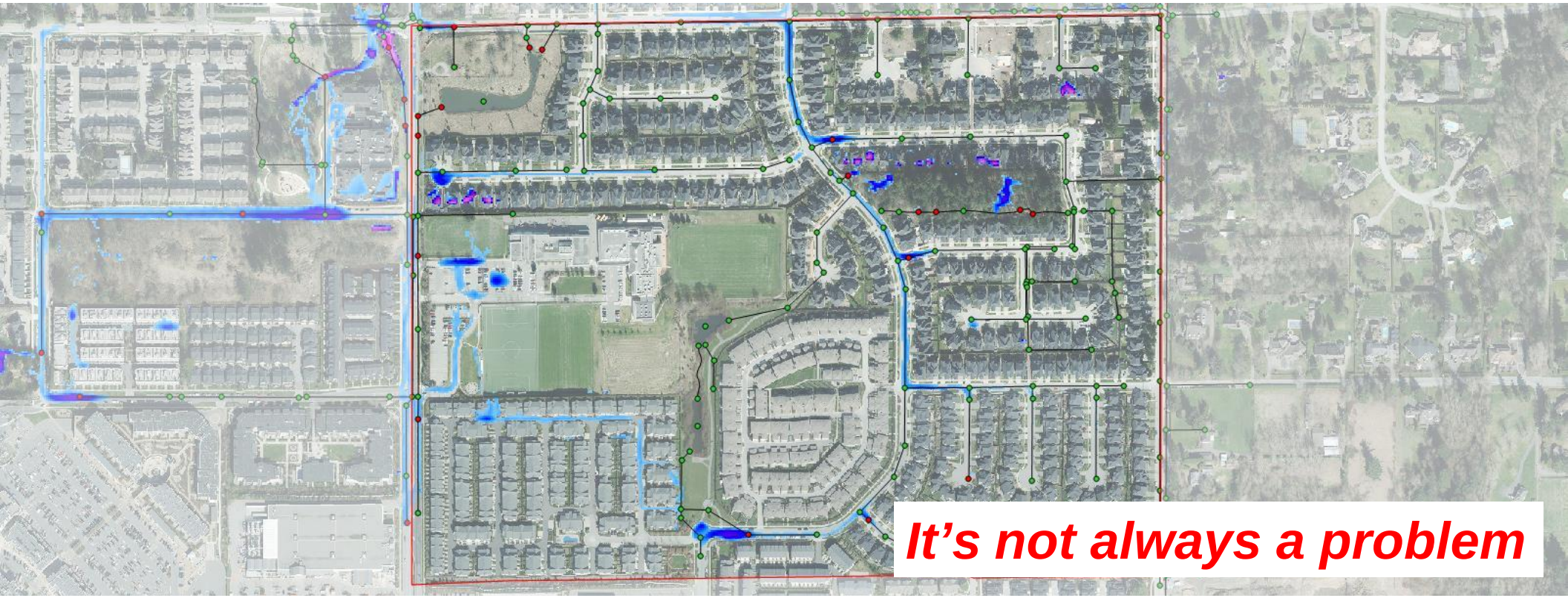
Summary

- Why evaluate overland flow?



Summary

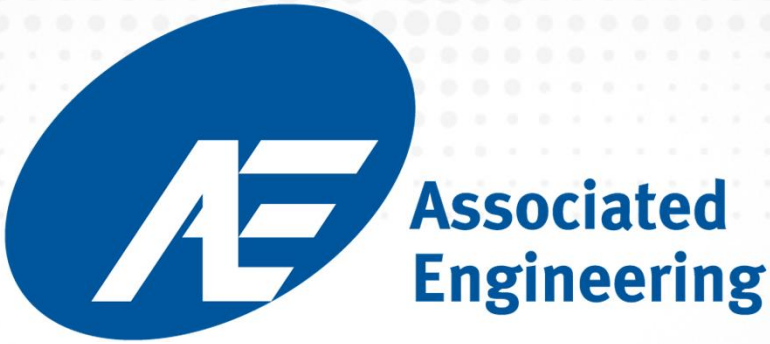
- Why evaluate overland flow?



Summary

- Why evaluate overland flow?

Questions?



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