Incorporating Increasingly Extreme Weather Events in Water Infrastructure Planning

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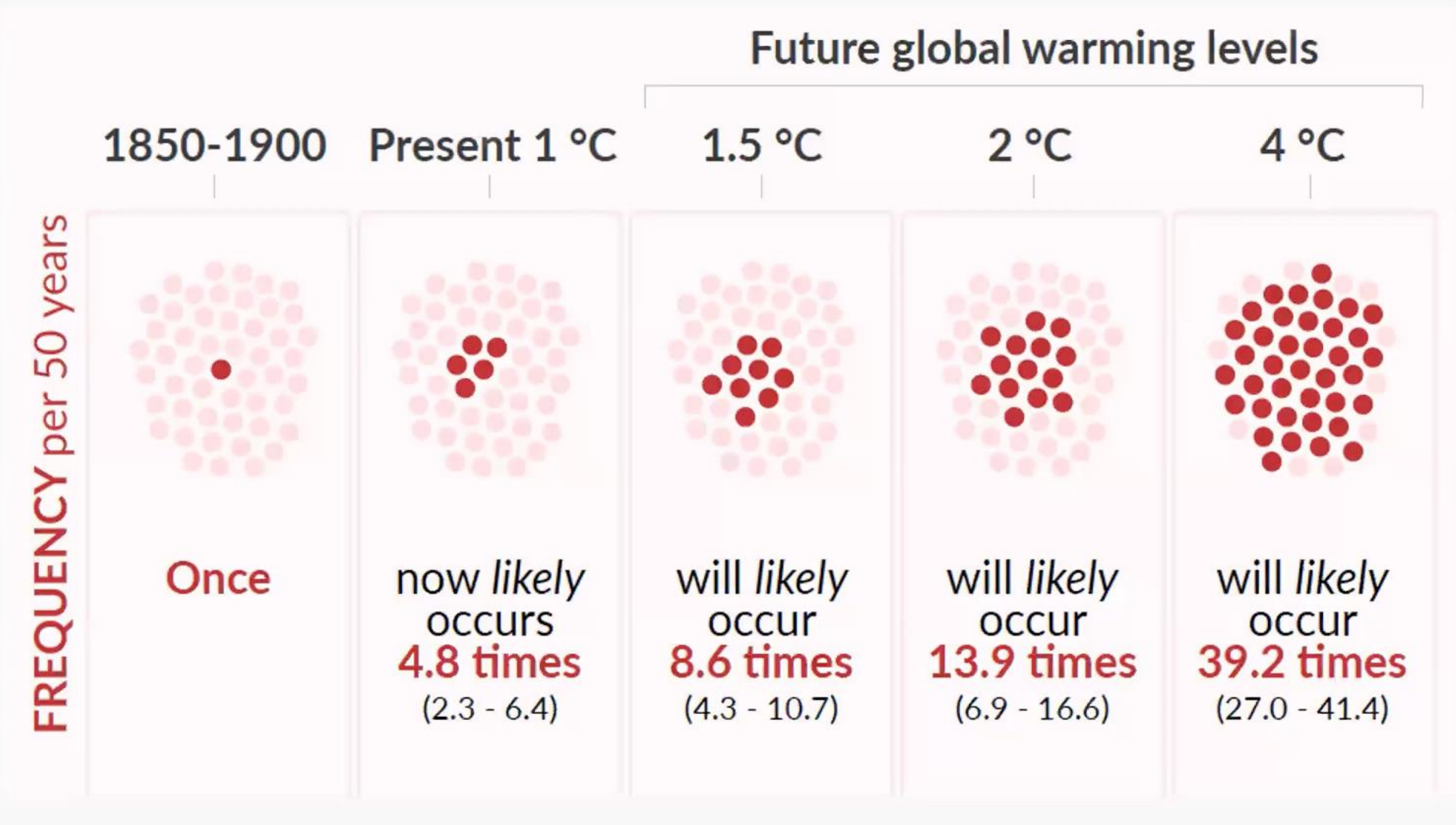
Overview

- Extreme weather is occurring more frequently and with more intensity than climate modelling has predicted
- Our observational record may not be long enough to effectively predict extreme events
- New methods are needed to effectively forecast and plan for future extreme events
- We will explore a few practical examples

Context: Unprecedented High Temperature Events

Erich Fischer, Institute for Atmospheric and Climate Science, ETH Zurich.
Presentation to PCIC Pacific Climate Seminar Series, December 2023.



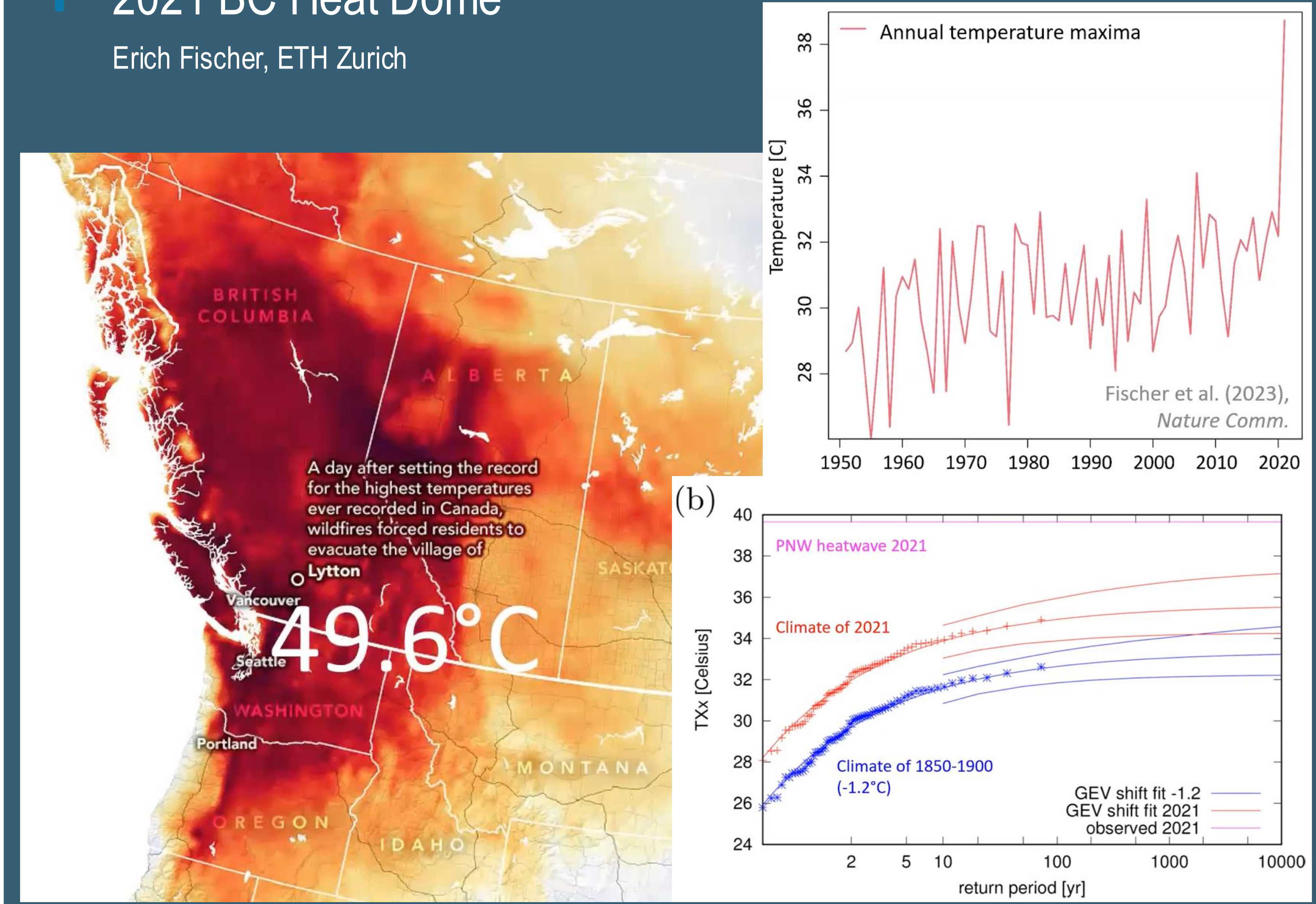
(IPCC AR6 WG1, Fig. SPM.6)

Extreme events are becoming more frequent

1. Frequency of extreme events increases *exponentially* with global average temperature
2. High likelihood that events of *unprecedented* intensity, duration and/or spatial extent will occur in the future

2021 BC Heat Dome

Erich Fischer, ETH Zurich



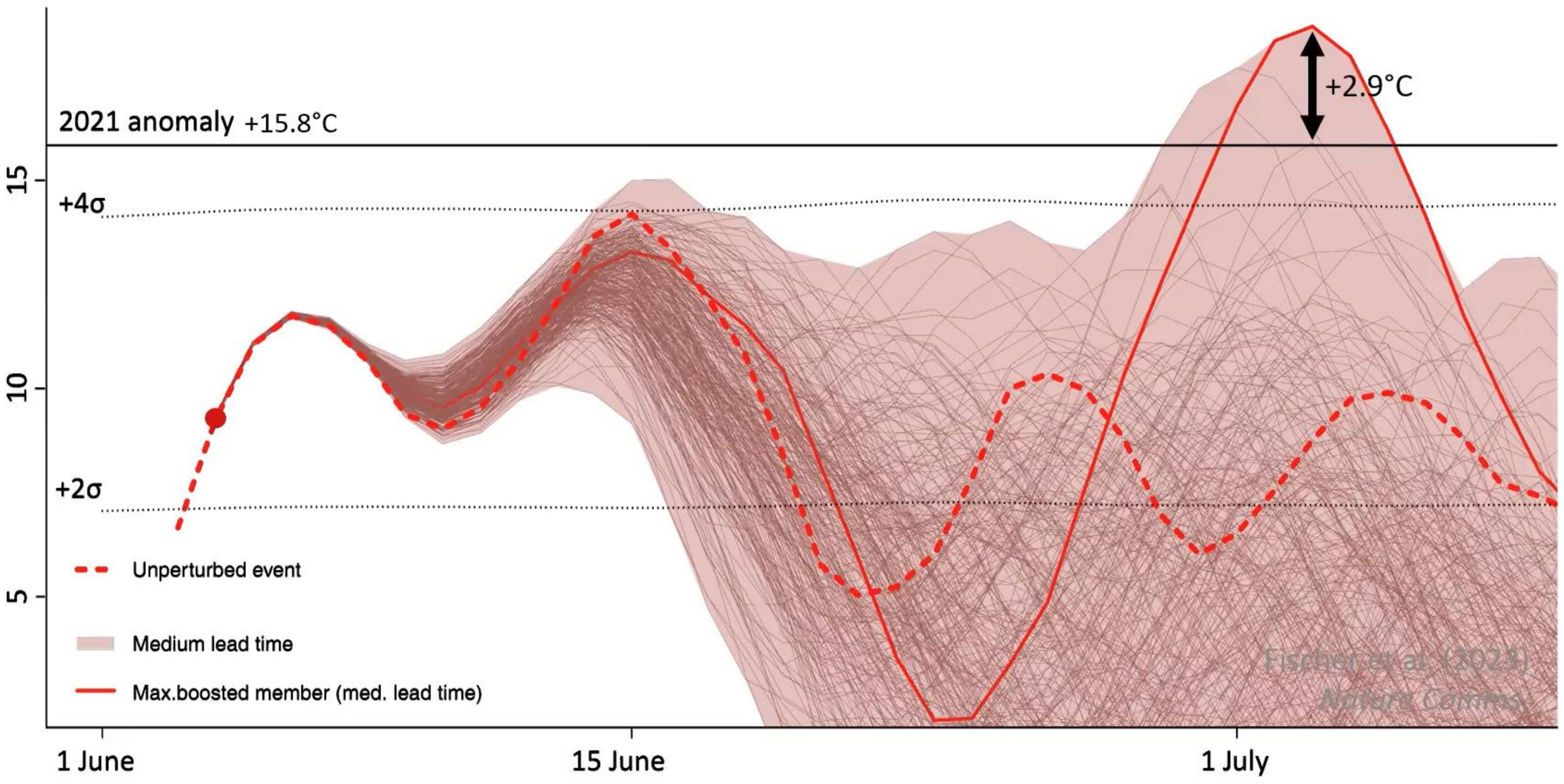
2021: A year of unprecedented events in BC

June 2021 heat dome exceeded previous temperature record by 5ºC

This event had a *probability less than zero* based on the historical record, even after adjusting for 2021 climate

How can we forecast and plan for extreme events?

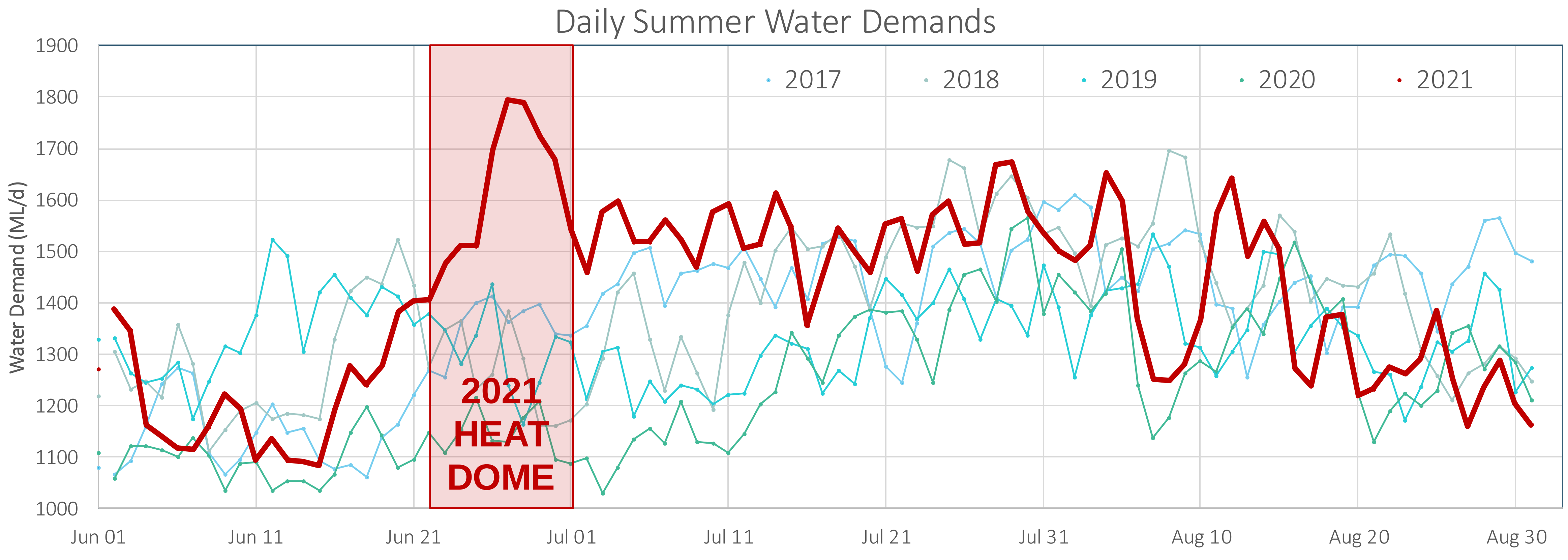
Erich Fischer, ETH Zurich



Consider *multiple lines of evidence* to build confidence in predictions: “Storylines”:

- Add a very small “perturbation” to the long-range weather forecast of an extreme event → shows how readily extreme events can become even more intense than probabilistic models predict
- “Hindcast”: Consider past long-range (2-3 week) weather forecast modelling for extreme events, including those that did not happen
- Consider “near misses” in space: Extreme events that occurred near population centres
- Superimpose past extreme events on current climate using models

Peak Water Demand Forecasting for Water Supply Infrastructure Planning and Design

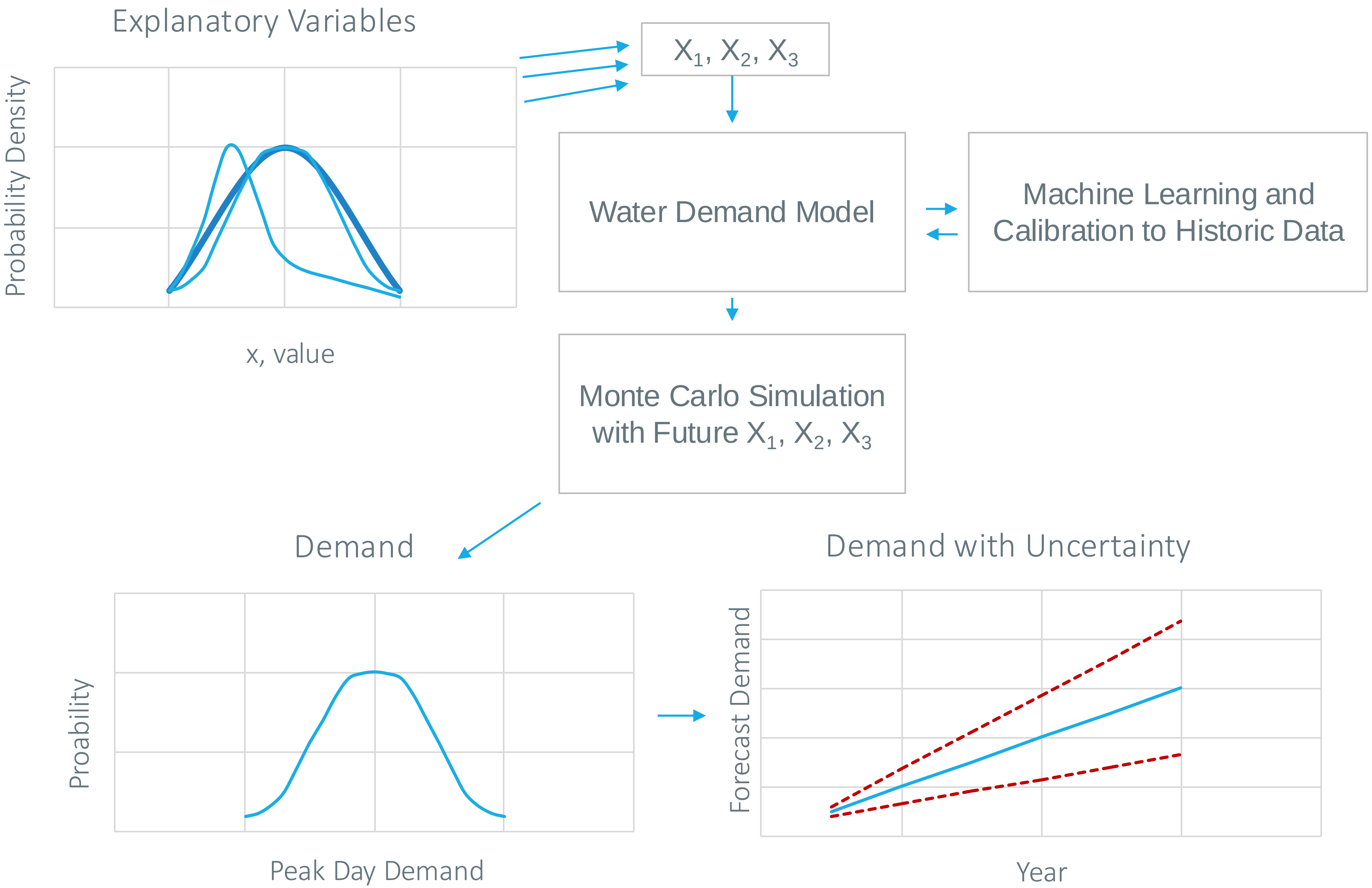


Peak Day Demand Uncertainty - Monte Carlo Simulation

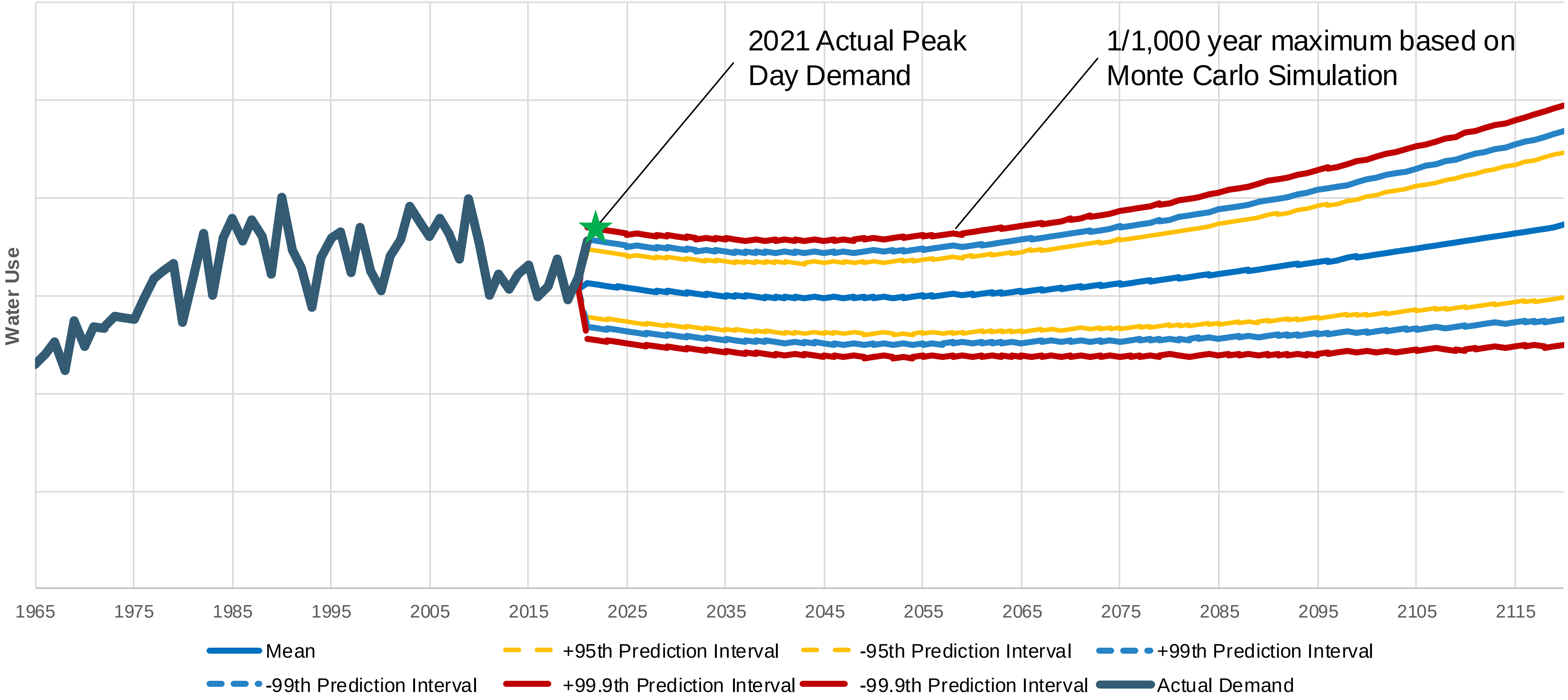
1. Determine relationship between max temperature and peak water demand (historical)

2. Develop a future water demand distribution for future climate using downscaled climate forecast

3. Run Monte Carlo incorporating climate and other explanatory variables



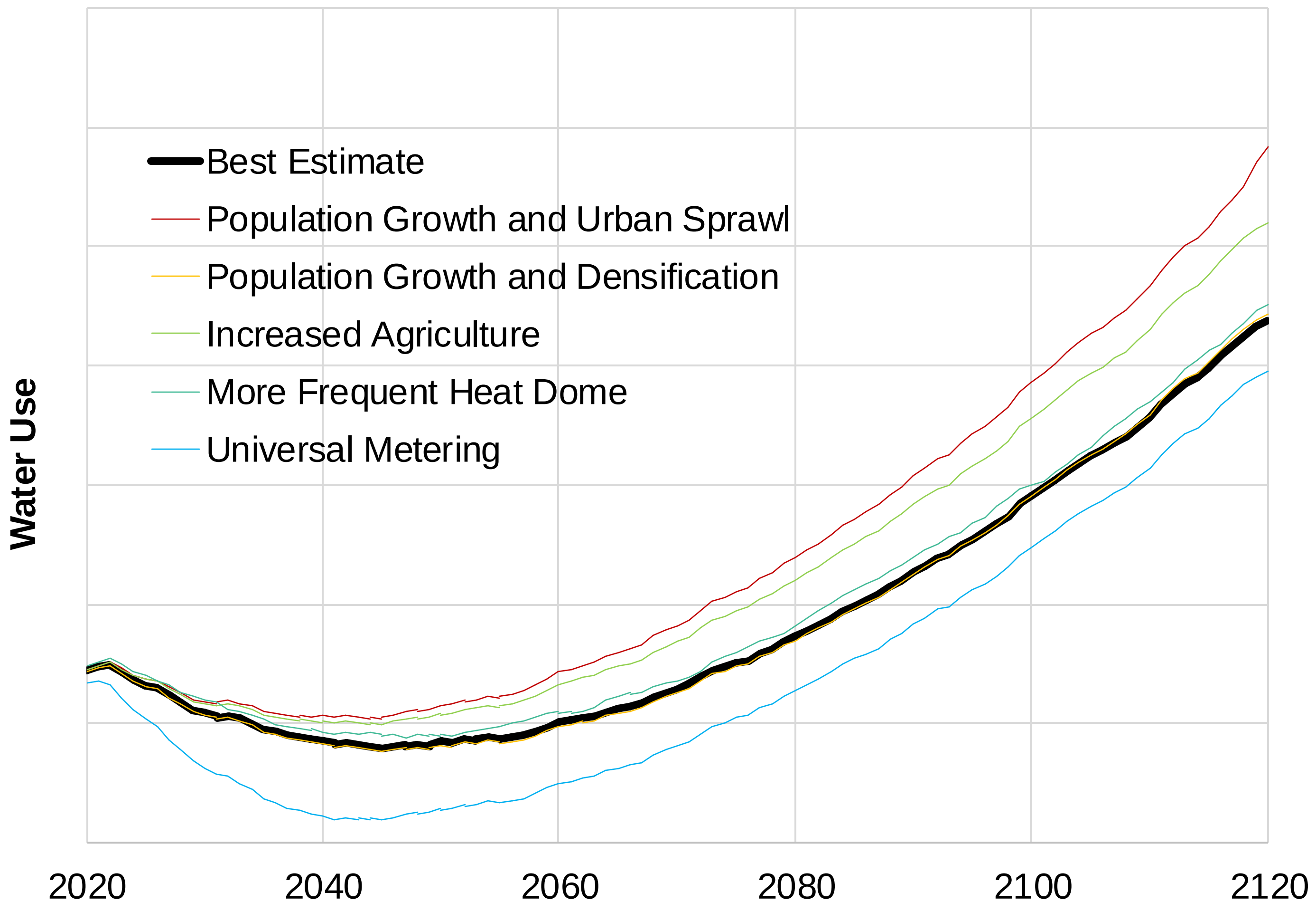
Validation and Scenario Analysis



Example scenario: 2021 heat dome event represents 20-year return period event in future

+ Apply Scenarios for Major Water Supply Infrastructure Planning

- Apply highest probable forecast of serviced population
- Use 1,000 year historical return period peak day demand event for new supply infrastructure design (approx. equivalent to 2021 heat dome event)
- Account for:
  - indoor water efficiency improvements
  - Increases in price of water
  - Universal residential metering



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Design Examples

Supply watermain – 20% size reduction

Parameter	Old Methodology	New Methodology
Forecast Per Capita Demand (2065)	782 L/cap/day	471 L/ cap/day
% Service Area	9.66%	9.66%
Population	76,000	76,000
PDD	59 ML/day	36 ML/day
Nominal Pipe Size	1050 mm	850 mm

Reservoir – 15% size reduction

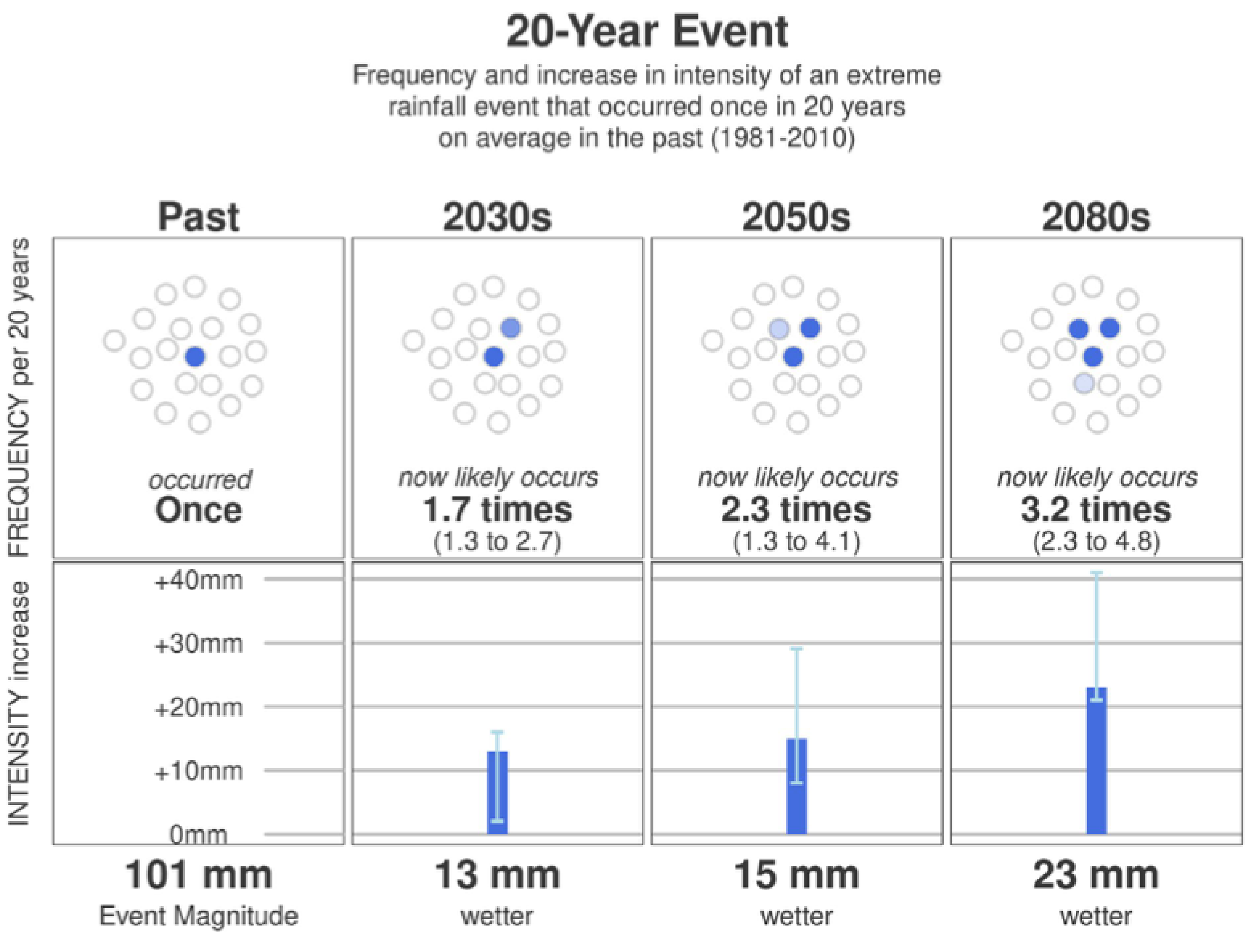
Parameter	Old Methodology	New Methodology
Forecast Per Capita Demand (2046)	603 L/cap/day	510 L/cap/day
Service Area	6.56 % of municipality	6.56 % of municipality
Population	55,729	55,729
PDD	33.6 ML/day	28.4 ML/day
Capacity (25% of PDD)	8.4 ML	7.1 ML

Adjusting IDF Curves for Stormwater Design

- Frequency of extreme rainfall events increases more linearly with time or global average temperature than extreme high temperature events

- Relative changes in IDF curves are not constant across event duration and return period

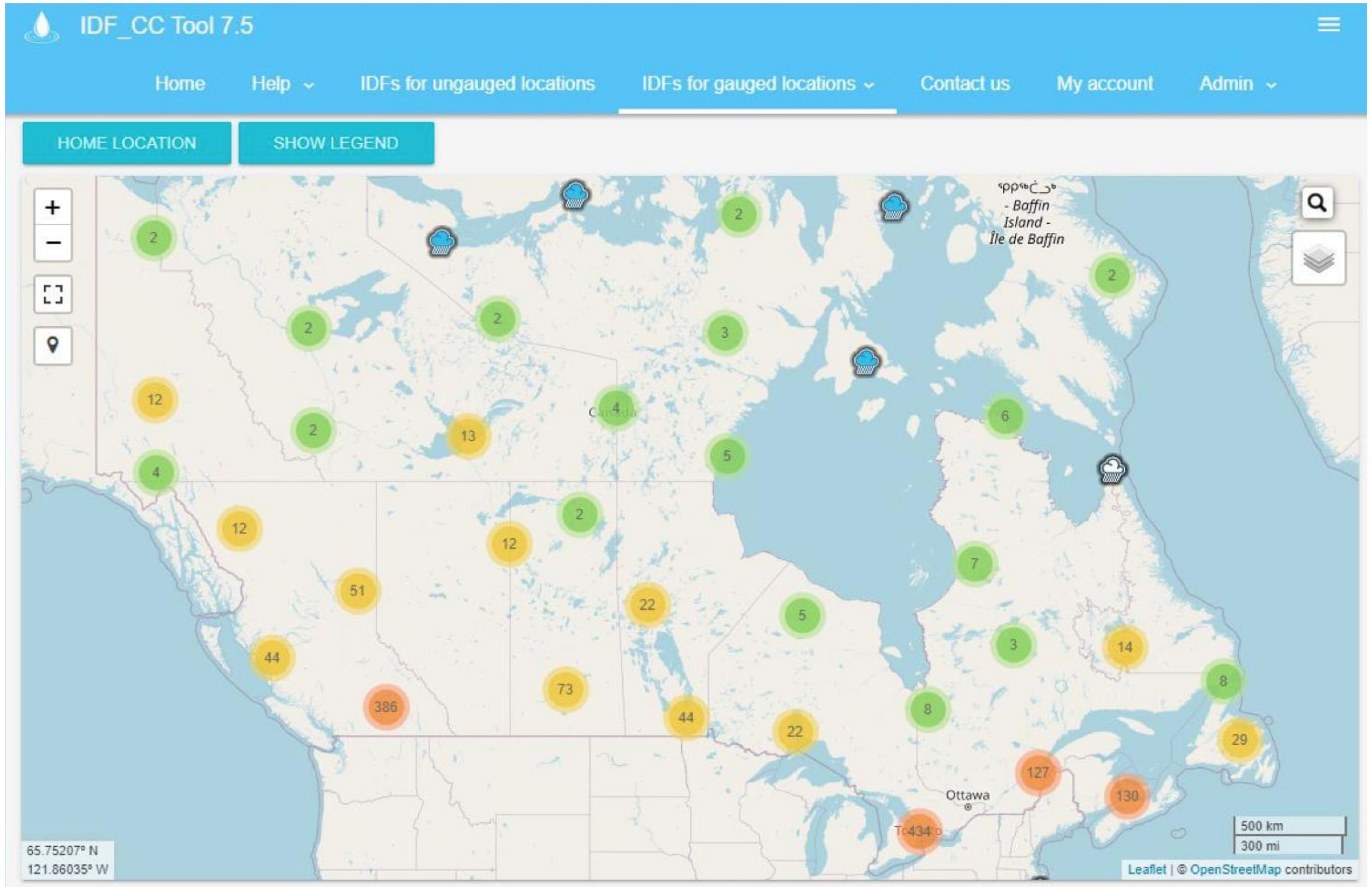
  → a single adjustment factor cannot be used to accurately adjust an IDF curve



Capital Regional District and Pacific Climate Impacts Consortium – *Climate Projections for the Capital Region*, 2024

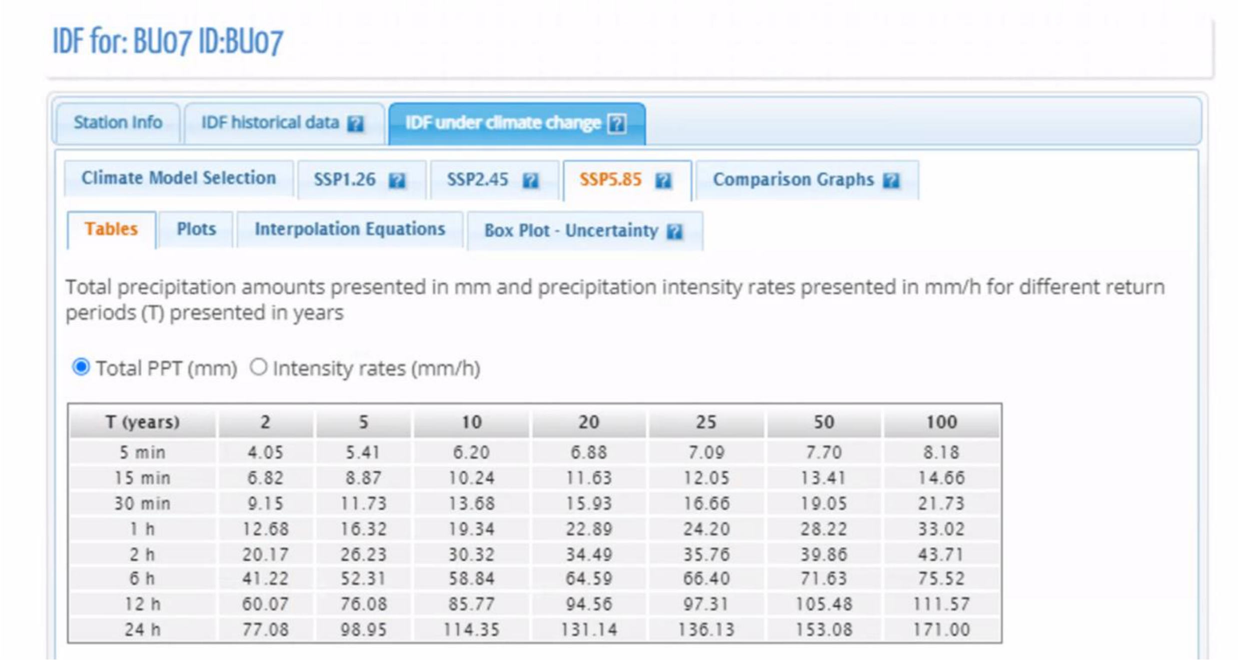
IDF-CC Tool v.7.5 (Western University)*

- Web-based, publicly available
- 898 gauged locations across Canada
- Gridded data for ungauged locations
- User-selectable:
  - Time horizon
  - Global climate model/ensemble

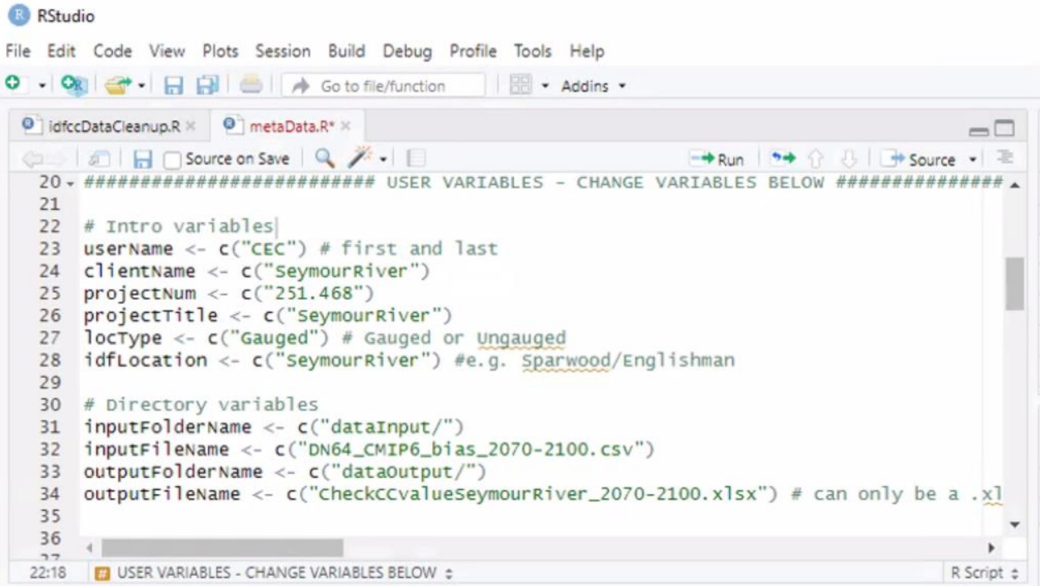


*Simonovic, S.P., A. Schardong, R. Srivastav, and D. Sandink (2015), IDF_CC Web-based Tool for Updating Intensity-Duration-Frequency Curves to Changing Climate – ver 7.5, Western University Facility for Intelligent Decision Support and Institute for Catastrophic Loss Reduction, open access https ://www.idf-cc-uwo.ca

IDF data processing



T (years)	2	5	10	20	25	50	100
5 min	4.05	5.41	6.20	6.88	7.09	7.70	8.18
15 min	6.82	8.87	10.24	11.63	12.05	13.41	14.66
30 min	9.15	11.73	13.68	15.93	16.66	19.05	21.73
1 h	12.68	16.32	19.34	22.89	24.20	28.22	33.02
2 h	20.17	26.23	30.32	34.49	35.76	39.86	43.71
6 h	41.22	52.31	58.84	64.59	66.40	71.63	75.52
12 h	60.07	76.08	85.77	94.56	97.31	105.48	111.57
24 h	77.08	98.95	114.35	131.14	136.13	153.08	171.00

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########################## USER VARIABLES - CHANGE VARIABLES BELOW ###############

# Intro variables
userName <- c("CEC") # first and last
clientName <- c("SeymourRiver")
projectNum <- c("251.468")
projectTitle <- c("SeymourRiver")
locType <- c("Gauged") # Gauged or Ungauged
idfLocation <- c("SeymourRiver") #e.g. Sparwood/Englishman

# Directory variables
inputFolderName <- c("dataInput/")
inputFileName <- c("DN64_CMIP6_bias_2070-2100.csv")
outputFolderName <- c("dataOutput/")
outputFileName <- c("CheckCCvalueSeymourRiver_2070-2100.xlsx") # can only be a .xl
```

KWL uses a tool built in R to run data cleanup and statistical analysis on IDF-CC outputs

- Produces clean, readable file for use in Excel
- KWL standard practice is to convert outputs to % increase for each duration and return period…Enables comparison across all GCMs and confidence intervals for each projection (P25, 50, 75, 95, 99 etc.)

Recommendations for using IDF forecasts

"As a conservative approach for infrastructure sizing amid uncertainty for future greenhouse gas emissions, the SSP5.85 (former RCP8.5) scenario is typically used to predict climate change impacts. The SSP5.85 applies higher greenhouse gas emissions rates and the upper boundary of the range of predictions for future warming, when compared to the SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 scenarios, which in turn leads to more severe climate change predictions."

- Degree of conservatism must be considered on a case-by-case basis
- Ensure methods are transparent to prevent safety factors on safety factors
- Consider the source and quality of the baseline IDF curve when applying percentage increases on it
- Ensemble median for SSP5.85 represents a moderate or most-likely scenario
- Use 95th percentile on the 100 year event where failure consequence is high or catastrophic

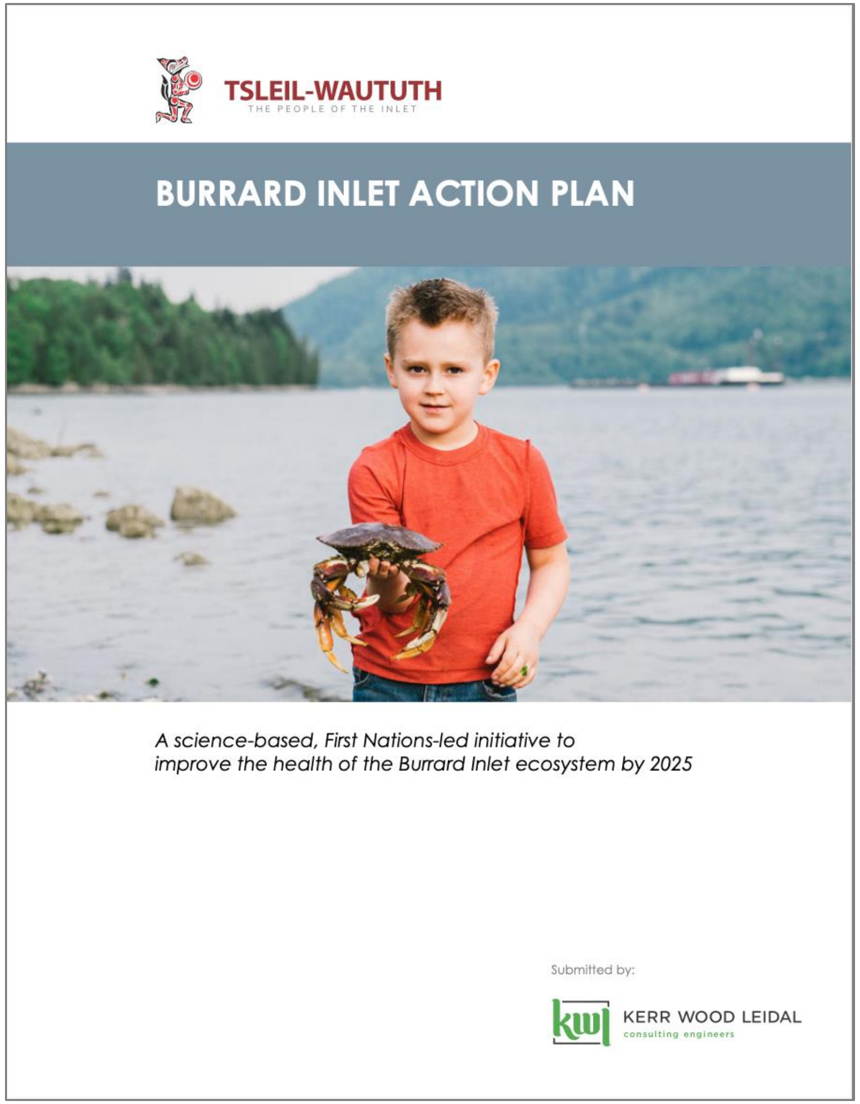
Climate Change Factors		
Return Period	Median	95th Percentile
2-year	15% - 15%	21% - 22%
5-year	15% - 16%	25% - 25%
10-year	16% - 18%	27% - 28%
25-year	17% - 20%	31% - 33%
50-year	18% - 20%	33% - 37%
100-year	17% - 21%	36% - 39%

Median increase on values up to the 50-year storm event, suitable for infrastructure with a low to median risk for failure (i.e. storm sewers) or where major conveyance is available

95th Percentile increase 100-year + storm event, used when **consequence of failure is high or catastrophic failure** (i.e. creeks)

Sewer overflow management

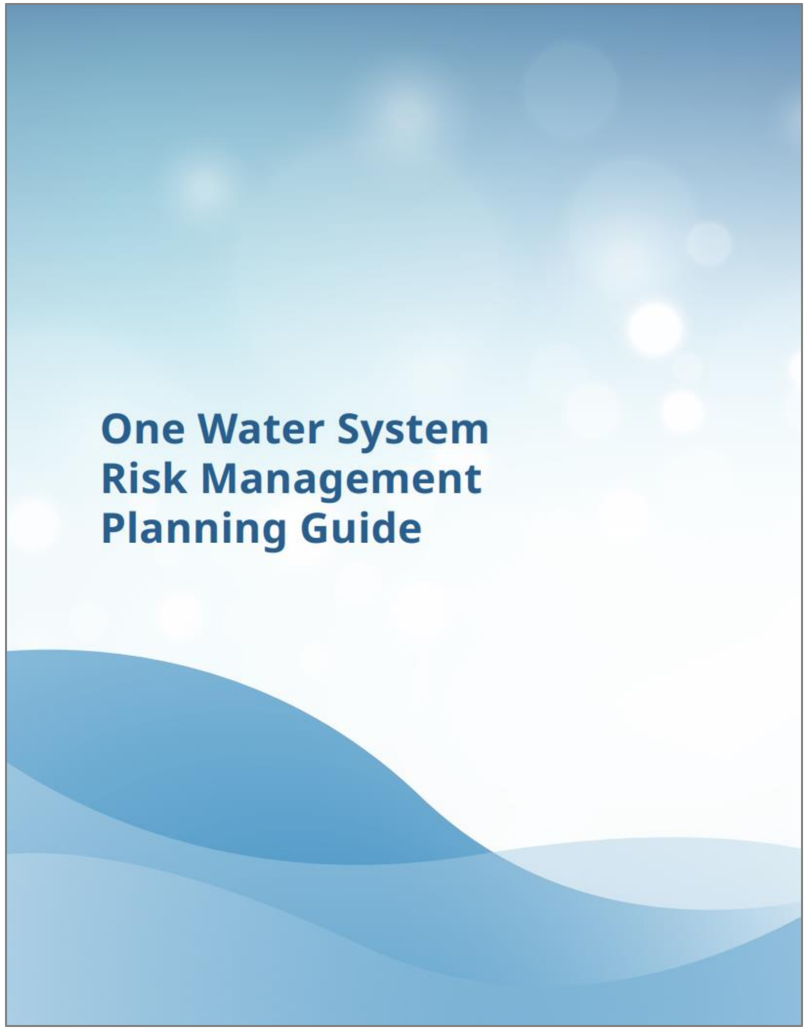
- Frequency and magnitude of overflows increases with climate change
- Regulatory limits may be based on historical return periods
- Receiving water quality (e.g. for shellfish harvesting) may be a primary driver for change
- Other climate change impacts including sea level rise exacerbate risks and mitigation costs
- Adjusted IDF curves alone are not a suitable tool due to the complexity of collection systems (e.g. groundwater infiltration)
- A suite of strategies must be assessed through forecast scenarios: e.g. Higher capacity rain gardens, larger pump stations, storage in collection systems, and ongoing separation over time
- Coordination across local, regional, provincial, federal and Indigenous governments is necessary

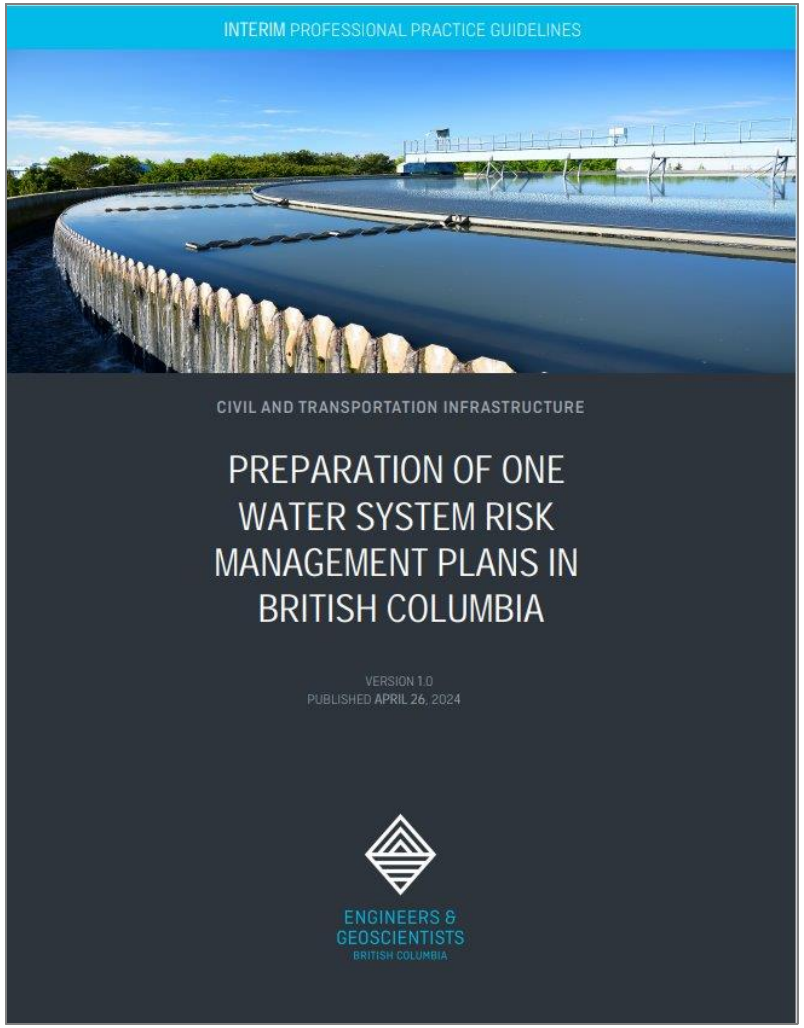


Assessing risks arising from interaction between water systems

New resources from Engineers and Geoscientists BC

- Enterprise risk / whole community focus
- All "waters"
- Scoping and screening tools
- Multidisciplinary





Summary

- Build *storylines* using *multiple lines of evidence* to support decisions that increase resiliency against future extreme events
- Consider *interactions* between systems
- *Collaborate* across jurisdictions and professional disciplines

Thank you!