Stantec

HOLISTIC FLOOD MANAGEMENT AND MODELING UNDER CLIMATE IMPACTS

FSA JUNE 2023

THE Water Research FOUNDATION

PROJECT TEAM

Andrea Crumpacker

Eric Hersh *Ph.D., PE*

Mark Bartlett *Ph.D., PE*

Andrew Verdin *Ph.D.*

AGENDA

- Planning: Challenges and Solutions
- WRF 5084 – Data Analysis Techniques & Risk Planning Case Studies

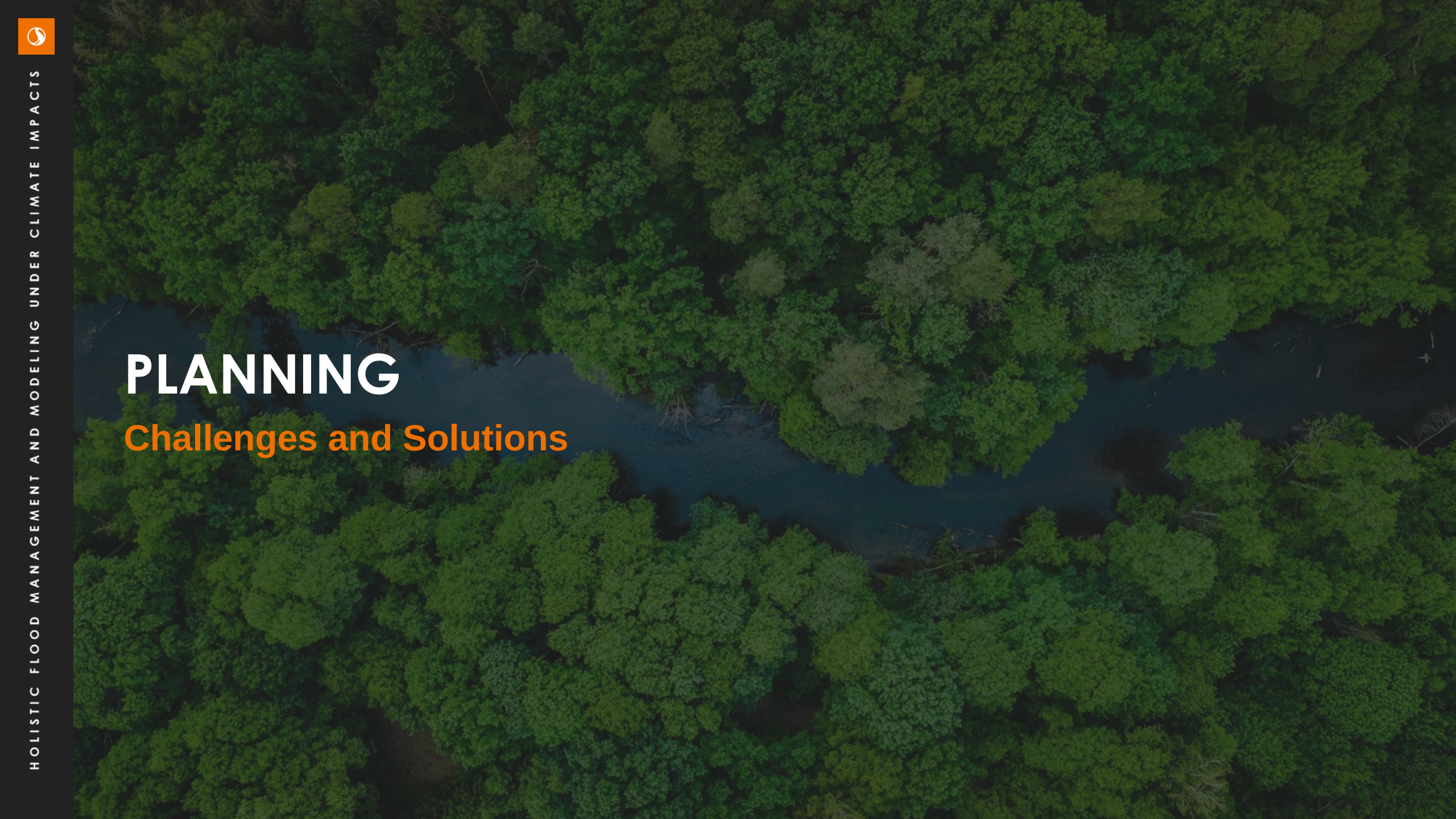
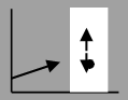
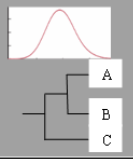
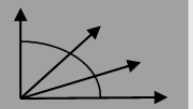
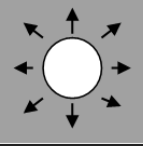

HOLISTIC FLOOD MANAGEMENT AND MODELING UNDER CLIMATE IMPACTS
PLANNING
Challenges and Solutions

Photo Credit: Bill Couch/Creative Commons

PLANNING IN THE FACE OF UNCERTAINTY

	A clear enough future (with sensitivity)
	Alternate futures (with probabilities)
	Alternate futures (with ranking)
	A multiplicity of plausible futures (unranked)
	Unknown future

Source: Walker et al. (2013)

DEFINING THE CHANGE

A changing climate means **previous assumptions of stationarity are no longer valid**

The **values and priorities** of many communities are changing

DEALING WITH CHANGE

Risk-based approaches are replacing a traditional focus on benefit-cost analysis or firm yield

A risk-based approach builds on a **solid foundation** of credible data, defensible modeling, transparent decision-making, and **input and buy-in** from stakeholders along the way

Multi-risk problems, **multi-benefit** solutions

WHAT THE FUTURE HOLDS

Changes in water policy and management

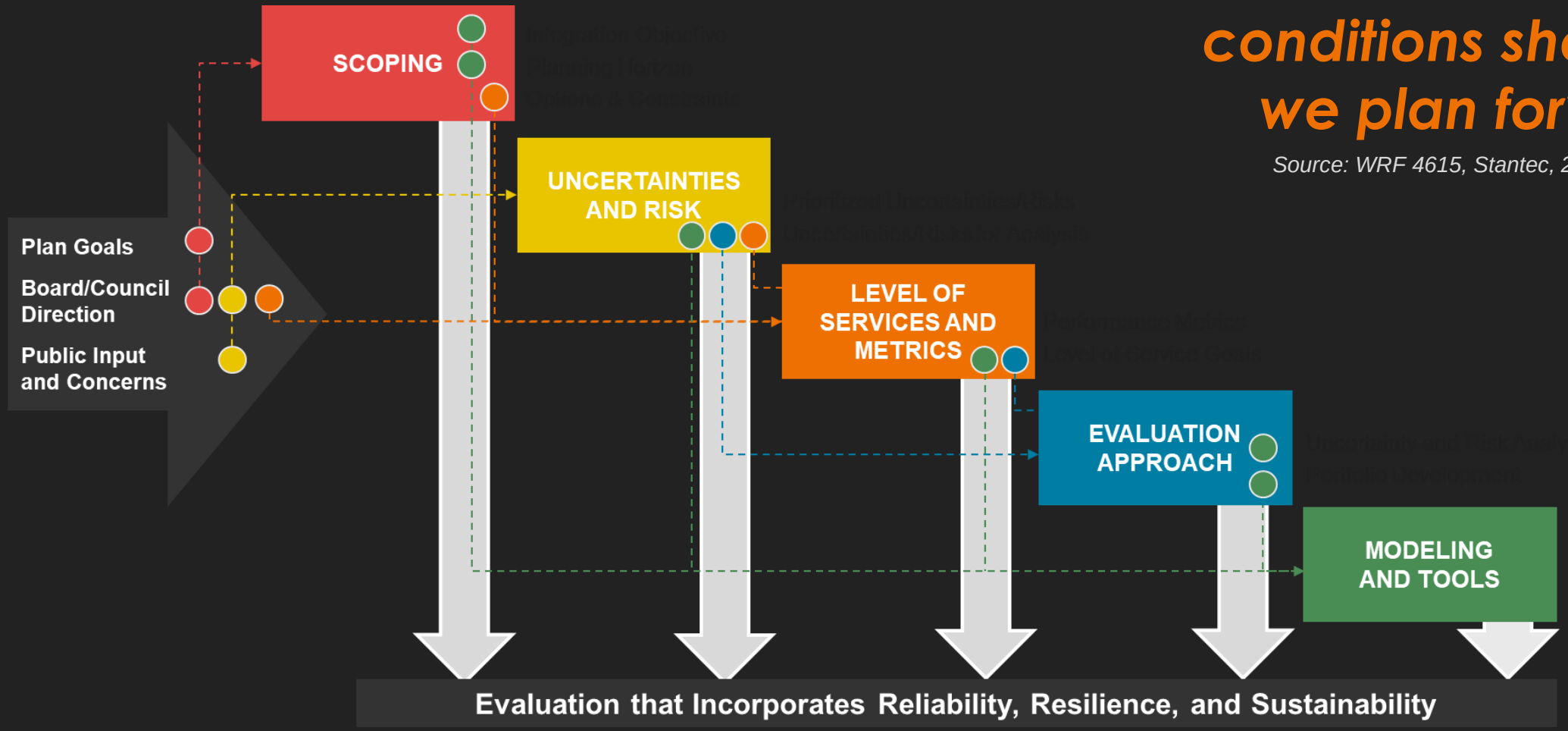
More diverse portfolios of **structural and non-structural** solutions

Increased **collaboration** with stakeholders and decision makers on cost-benefit **tradeoffs**

WATER RESOURCES EVALUATION FRAMEWORK

"What future conditions should we plan for?"

Source: WRF 4615, Stantec, 2017



https://www.waterrf.org/sites/default/files/file/2019-07/SWMC17-Paulson_etal.pdf

OBSTACLES AND SOLUTIONS FOR RISK-BASED PLANNING FOR SMALLER UTILITIES AND LIMITED BUDGETS

Source: WRF 4970, Stantec, 2019

LESSONS LEARNED: PLANNING IN THE FACE OF UNCERTAINTY

We can often **quantify risk**

Stable **frameworks, definitions, and processes** support transparent decision-making

A plan is most successful and most durable when it is **transparent and includes stakeholders** at every step of the way

Planning is **iterative**, you don't need to develop all tools and models the first time through the planning process

You have the **opportunity to learn about your organization and system** during the planning process

Uncertainty is often addressed through the use of different future **scenarios**

HOLISTIC AND INNOVATIVE FLOOD MITIGATION PLANNING AND MODELING UNDER EXTREME WET WEATHER EVENTS AND CLIMATE IMPACTS

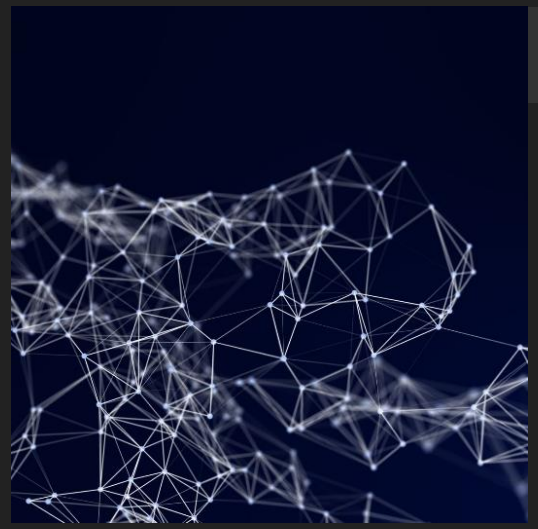
WRF5084 – Case Studies

PROJECT APPROACH

THE Water Research FOUNDATION

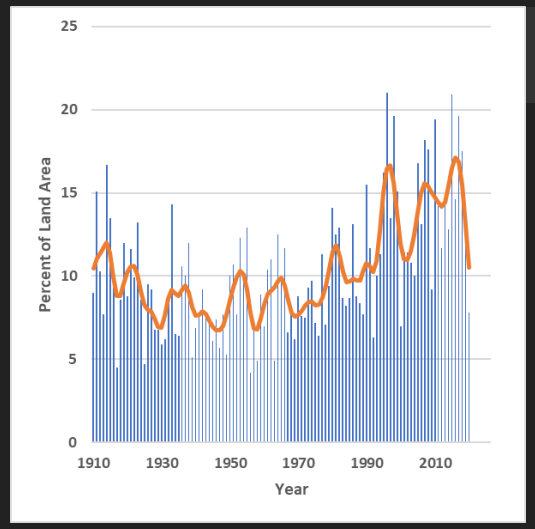
https://www.waterrf.org/research/projects/holistic-and-innovative-approaches-flood-mitigation-planning-and-modeling-under

1	LITERATURE REVIEW	Perform research on practice and innovative approaches for holistic flood management and flood scenario modeling
2	CASE STUDIES	Conduct a series of utility case study interviews and summaries
3	VIRTUAL WORKSHOP	Conduct workshops of experts to develop the foundation of the guidance document
4	GUIDANCE DOCUMENT	Develop a guidance document on holistic flood mitigation planning and modeling
5	REPORTS	Report findings of the study and provide public outreach on results achieved



01

Industry-standard flood models are inadequate in handling uncertainty in simulating and validating extreme rainfall events



Source: USEPA Climate Change Indicators

02

Intense precipitation events are occurring at higher frequency; existing global climate models cannot fully inform

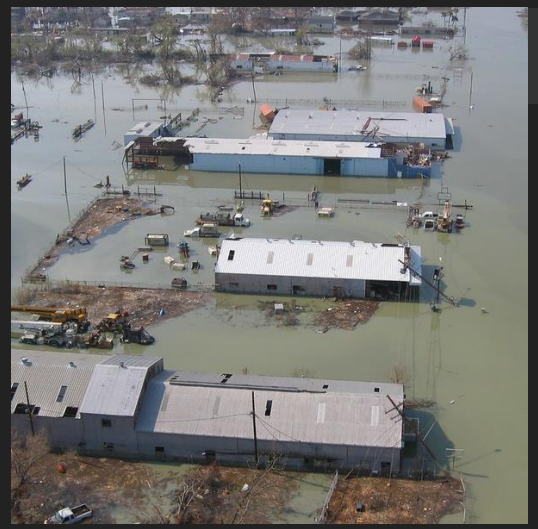


Image credit: Lieut. Commander Mark Moran, NOAA Corps, NMAO/AOC.

03

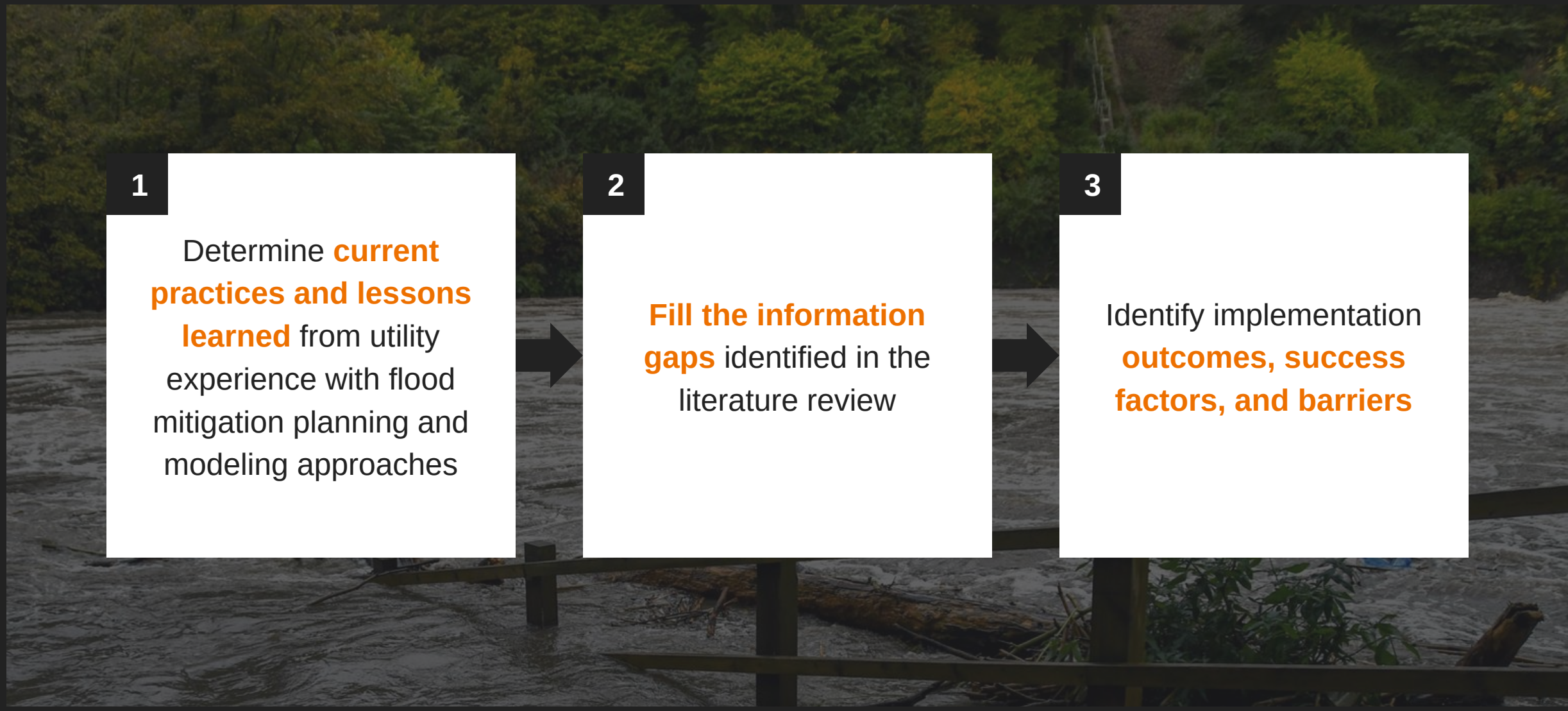
Low income and minority populations are disproportionately affected

Image credit: Port of San Francisco

04

Successful flood mitigation management plans require overcoming technical barriers *and* communicating cost and benefits to the public *and* collaborating across public agencies and government sectors

CASE STUDY OBJECTIVES



1

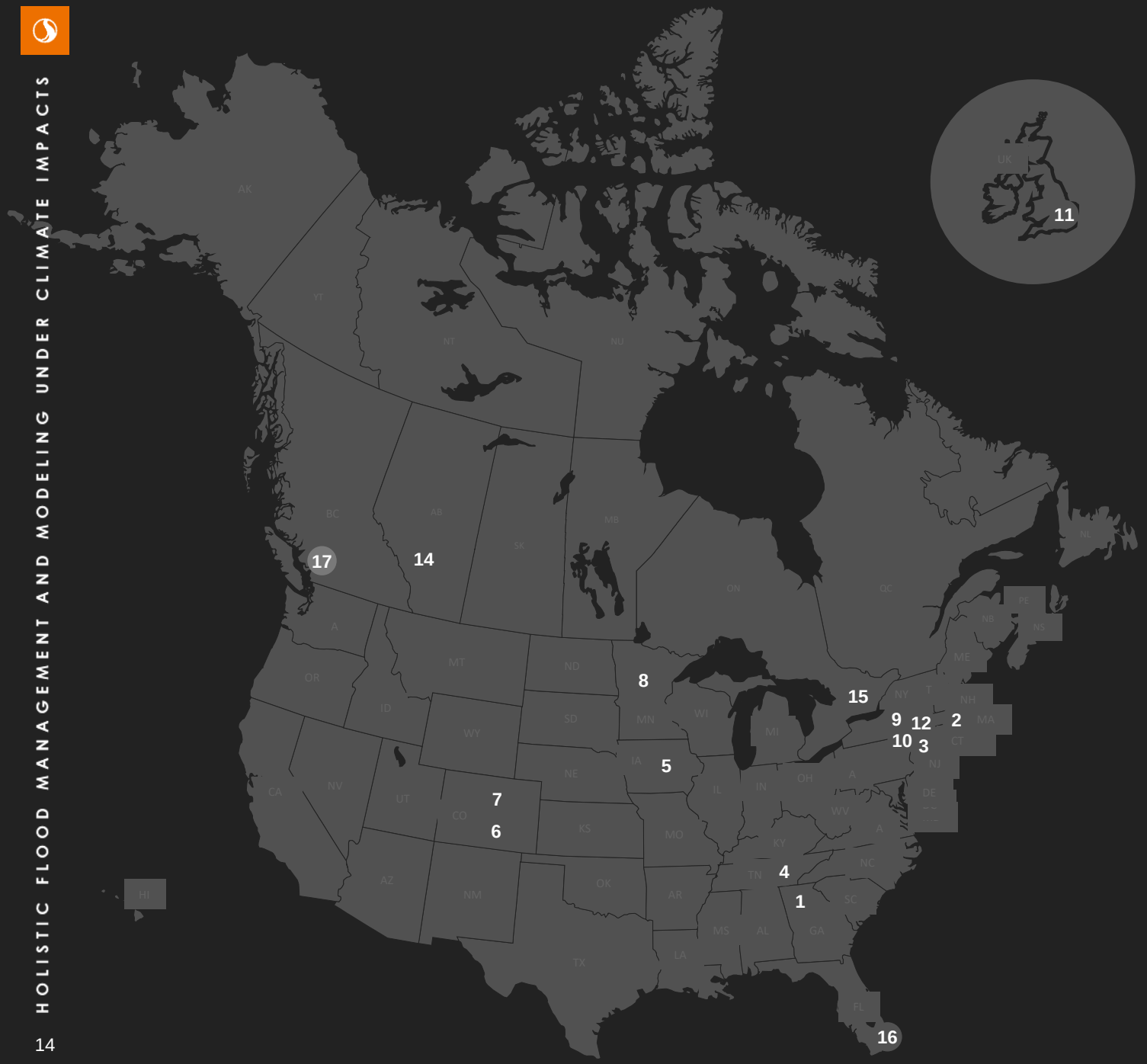
Determine **current practices and lessons learned** from utility experience with flood mitigation planning and modeling approaches

2

Fill the information gaps identified in the literature review

3

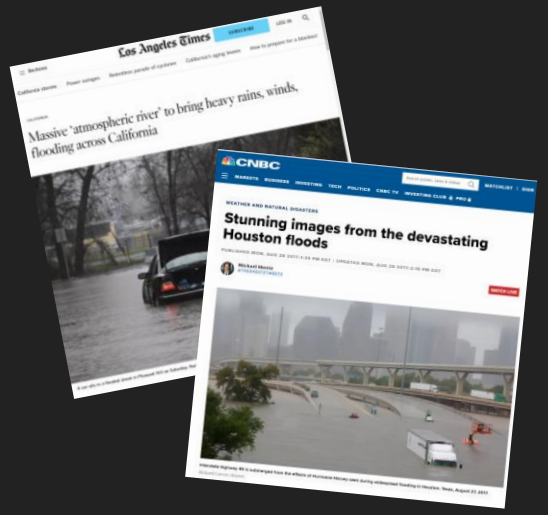
Identify implementation **outcomes, success factors, and barriers**



CASE STUDY PARTICIPANTS

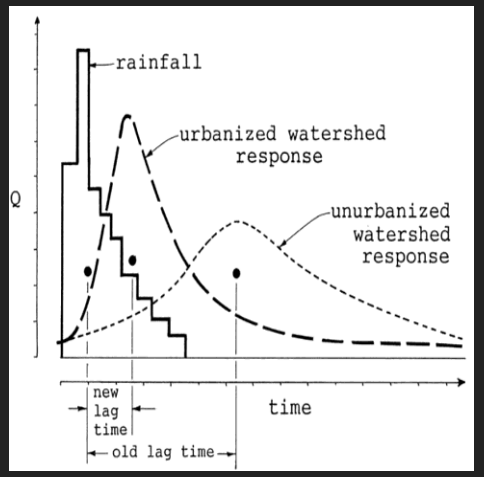
1. City of Atlanta, GA
2. City of Cambridge, MA
3. NYC Housing Authority
4. City of Chattanooga, TN
5. Iowa DNR
6. City of Colorado Springs, CO
7. Mile High Flood Control District, CO
8. Minnesota DNR
9. NYC Economic Development Corp.
10. NYC Mayor's Office
11. Stantec UK and Ireland (Urban Drainage and Flooding Lead)
12. NYC DEP
13. Santa Clara Valley Water District, CA
14. City of Calgary, AB
15. Toronto and Region Conservation Authority, ON
16. South Florida Water Management District
17. Metro Vancouver, Canada

RECURRING THEMES



Major storms create public awareness, and can garner public and political support to galvanize spending…

…but there is a limited window of opportunity



Source: Burke et al., 1998

Land use development has had a greater impact than climate change

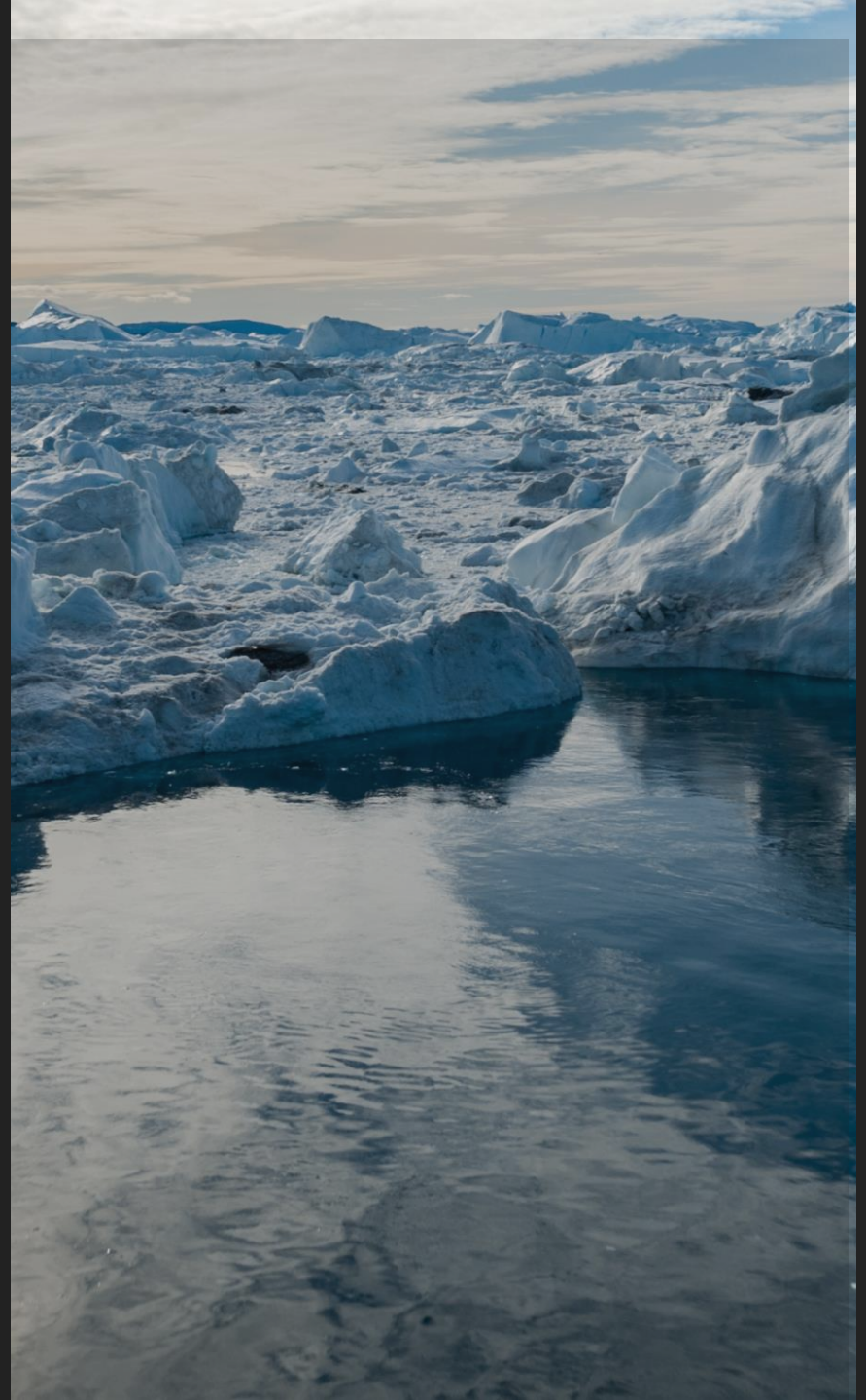
Image credit: Belmont Police Department New Years Eve 2022

High intensity, short duration events can be very impactful to stormwater drainage systems and are hard to model/predict

Source: FEMA | Source: Burke et al., 1998

FEMA maps are for insurance purposes

Updated maps are for decision-making and emergency preparedness and response



INCORPORATING CLIMATE CHANGE

01

Communities are using **a wide variety** of design events, probabilities, and approaches to compound effects… but **nobody is using joint probabilities** of future coastal/SLR, pluvial, water table, and fluvial events and impacts

02

Many communities are using **freeboard to provide a factor of safety** to address uncertainty

03

In colder climate communities, **the nature of flooding is changing** (e.g., seasonality, rain on snow, ice jams)

EXAMPLE: PHILADELPHIA WATER DEPARTMENT

PWD Coastal Design Flood Elevations

Asset Criticality	Useful Life		
	Near-term End of useful life does not extend beyond 2050	**Mid-century** End of useful life: 2050-2075	**End-of-century** End of useful life 2075+
Non-critical assets	Current floodplain regulations apply	12 ft NAVD88	
Critical assets	Current floodplain regulations apply	13.75 ft NAVD88	End-of Century DFE OR 13.75 ft NAVD88 + Adaptative Management Plan

2060s					
MHHW	SLR (primary planning scenario)	100-yr (storm tide)	Wave Effects	Freeboard	Total
3.66 ft	2.89 ft	3.95 ft	1.5 ft	1.7 ft	13.75 ft
	Risk Tolerance		Uncertainty		

Courtesy Julia Rockwell, PWD

EXAMPLE: SOUTH FLORIDA WATER MANAGEMENT DISTRICT (SFWMD)

Currently:

- Mapping flood probability risk and system vulnerabilities, including inundation for various return period storms under current and future climate predictions & canal capacity reductions due to sea level rise

- Working with USACE to define a standardized Level of Service for new development design standards across Florida incorporating NOAA Atlas 14 & future rainfall projections

A remaining challenge:

- The modeling to incorporate coastal modeling into inland scenarios to develop joint probabilities under different climate change scenarios is expensive and difficult

COMMUNICATING RISK

AWARENESS	PLANNING	ENGAGEMENT	INNOVATION
"People are overall **more aware of and concerned with flooding now** than they have ever been"	Many communities have recently developed **Climate Adaptation/ Resiliency Plans**, including mitigation and adaptation elements	Many communities find value in **ongoing, proactive partnerships** (i.e., not-project based) with trusted local organizations and neighborhood groups	**Innovation abounds!** In-language engagement, outreach to realtors, incentivizing public participation, identifying multi-benefit opportunities

EXAMPLE: CITY OF CALGARY, ALBERTA

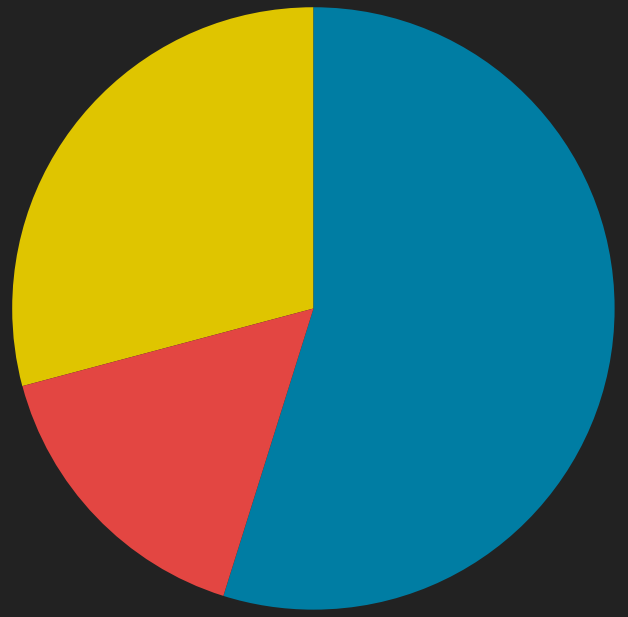
- **Disaster: 2013 Flood**
- Costliest natural disaster in Canadian history ($2B+ losses)

- **Response**
- 54% of 2013's exposure averted by 2020
- 71% of exposure will be averted by 2024
- Citizens groups consult, inform, and support
- Ongoing collaboration with Provincial government, NGOs, industry

Source: Ryan L. C. Quan, Creative Commons

Potential Flood Damages in Calgary

Total unmitigated potential annualized damages = $168M/yr



- Reduced to date (2021): $92M/yr
- Reduction from SR1: $27M/yr
- Residual potential damages: $49</yr

Courtesy Frank Frigo, City of Calgary

CHALLENGES REMAIN

In some cities, **land tends to be limiting factor**. Securing funding and public support for buy-outs is a challenge.

"Many climate solutions are **regional in nature** and beyond our borders, and there is a **need to build regional coalitions** (including governance structure and cost-sharing)."

"Fire is flood."

Wildfires are changing watershed hydrology.

Widespread desire for a **national-scale future climate projection**, akin to Atlas 14.

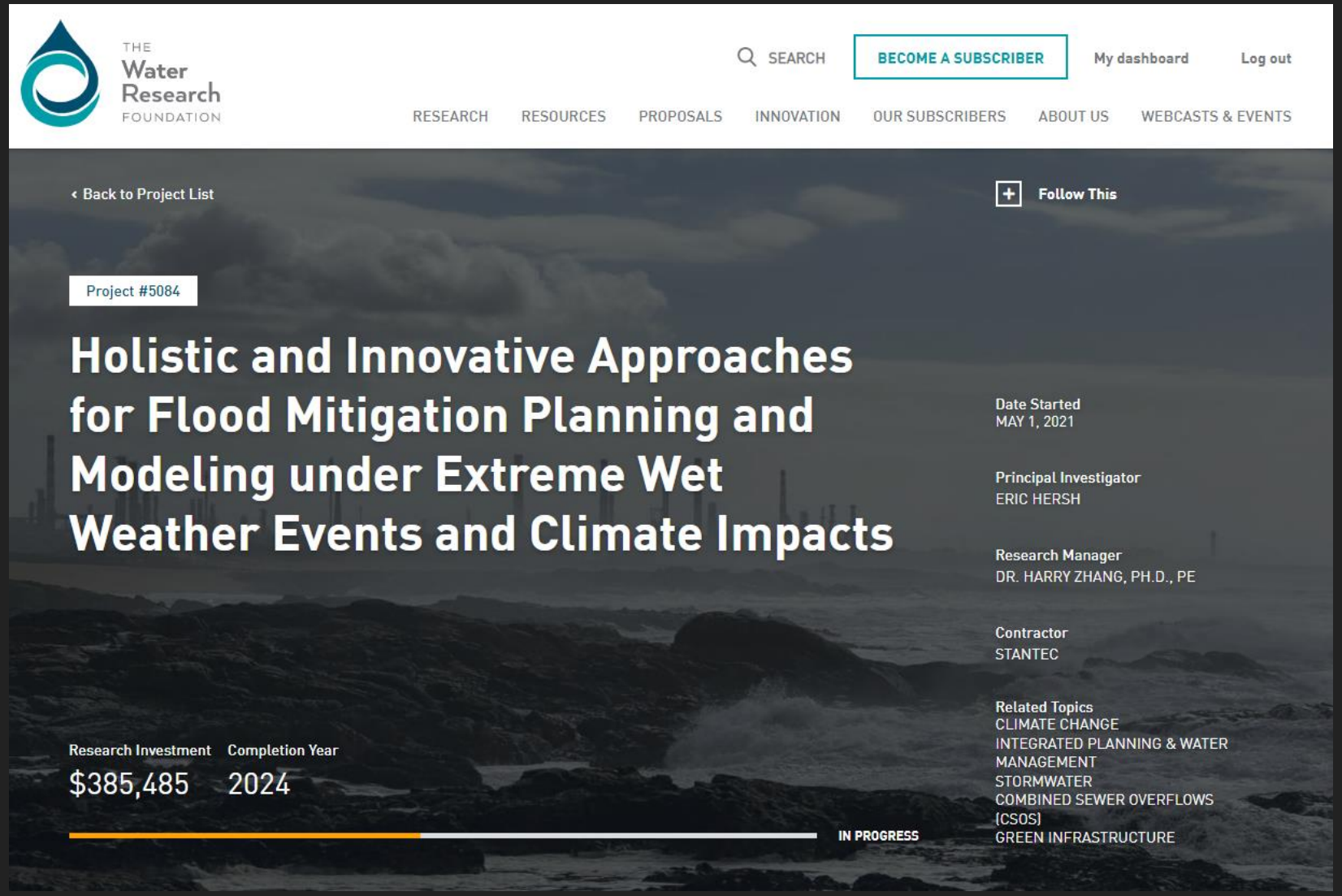
And of course: public apathy, funding, regulatory, better data and data integration, and staffing challenges.

IMPLEMENTING BEST PRACTICES

EMPHASIZE BUILDING IN RESILIENCE/ EXCEEDANCE PLANNING	E.g., instead of focusing on keeping out the 100-year design storm, **what happens when the 200-year storm occurs**?
SOCIAL VULNERABILITY MATTERS	Recasting flood planning from a **health and safety perspective** versus reducing economic damages. A paradigm shift, to “not monetize decision making.”
INNOVATION	Automated high-water road closure gates; emergency management coordination; funding more gages; using observational/ qualitative data for model; **living with water**
MAINTENANCE MATTERS	Capital funding is often a flood planning focus for flood planning, but **maintenance and operation is just as critical and often neglected**

EXAMPLE: BLUE-GREEN INFRASTRUCTURE IN HULL, ENGLAND

PRELIMINARY RESEARCH FINDINGS



Holistic and Innovative Approaches for Flood Mitigation Planning and Modeling under Extreme Wet Weather Events and Climate Impacts | The Water Research Foundation (waterrf.org)

NEXT STEPS

Guidance document designed to answer **FAQ's – Flood Answers and Questions –** via 9 modules:

- FAQ 1 – Flood Basics: Background on Flooding and Flood Risk
- FAQ2 – Methods to Determine Flood Risk
- FAQ3 – Considerations for Climate Change Impacts on Flooding
- FAQ4 – Flood Mitigation Planning
- FAQ5 – Incorporating Uncertainty into Flood Mitigation Planning
- FAQ6 – Leveraging Large Datasets and Novel Approaches for Flood Modelling and Mapping
- FAQ7 – Innovative Approaches to Flood Mitigation Planning
- FAQ8 – Stakeholder Engagement and Inclusion
- FAQ9 – Areas of Future Work

Anticipated Fall 2023 WRF publication.

FAQ's – Flood Answers and Questions

Which FAQ modules are for you?

I am…	Start with questions…
just getting started	1a-c, 2a-c, 4a-c, 8b
interested in H&H modeling	2b-e, 3k
interested in climate modeling	3a-l
interested in communications	8a-f
interested in equity and social vulnerability	8g-i
interested in leveraging machine learning	6a-e
interested in addressing uncertainty and risk	5a-j, 4b-d
interested in integrating stormwater and wastewater planning	4e-j
a small utility	4h
an innovator	7a-d, 6c-d, 8c-e

QUESTIONS AND ADDITIONAL INFORMATION

QUESTIONS

Andrea Crumpacker

Andrea.Crumpacker@stantec.com

Eric Hersh *Ph.D., PE*

eric.hersh@stantec.com

Mark Bartlett *Ph.D., PE*

andrew.verdin@stantec.com

Andrew Verdin *Ph.D.*

mark.bartlettjr@stantec.com

Thank you for participating!

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ADDITIONAL INFORMATION

- WRF 5084: Holistic and Innovative Approaches for Flood Mitigation Planning and Modeling under Extreme Wet Weather Events and Climate Impacts, https://www.waterrf.org/research/projects/holistic-and-innovative-approaches-flood-mitigation-planning-and-modeling-under
- WRF 4615: Framework for Evaluating Alternative Water Supplies: Balancing Cost with Reliability, Resilience, and Sustainability, https://www.waterrf.org/sites/default/files/file/2019-07/SWMC17-Paulson_etal.pdf
- WRF 4970: Obstacles and Solutions for Risk-Based Planning for Smaller Utilities and Limited Budgets, https://www.waterrf.org/research/projects/obstacles-and-solutions-risk-based-planning-smaller-utilities-and-limited-budgets