

Blue Cities 2018  
Canadian Water Network  
Toronto, May 1, 2018

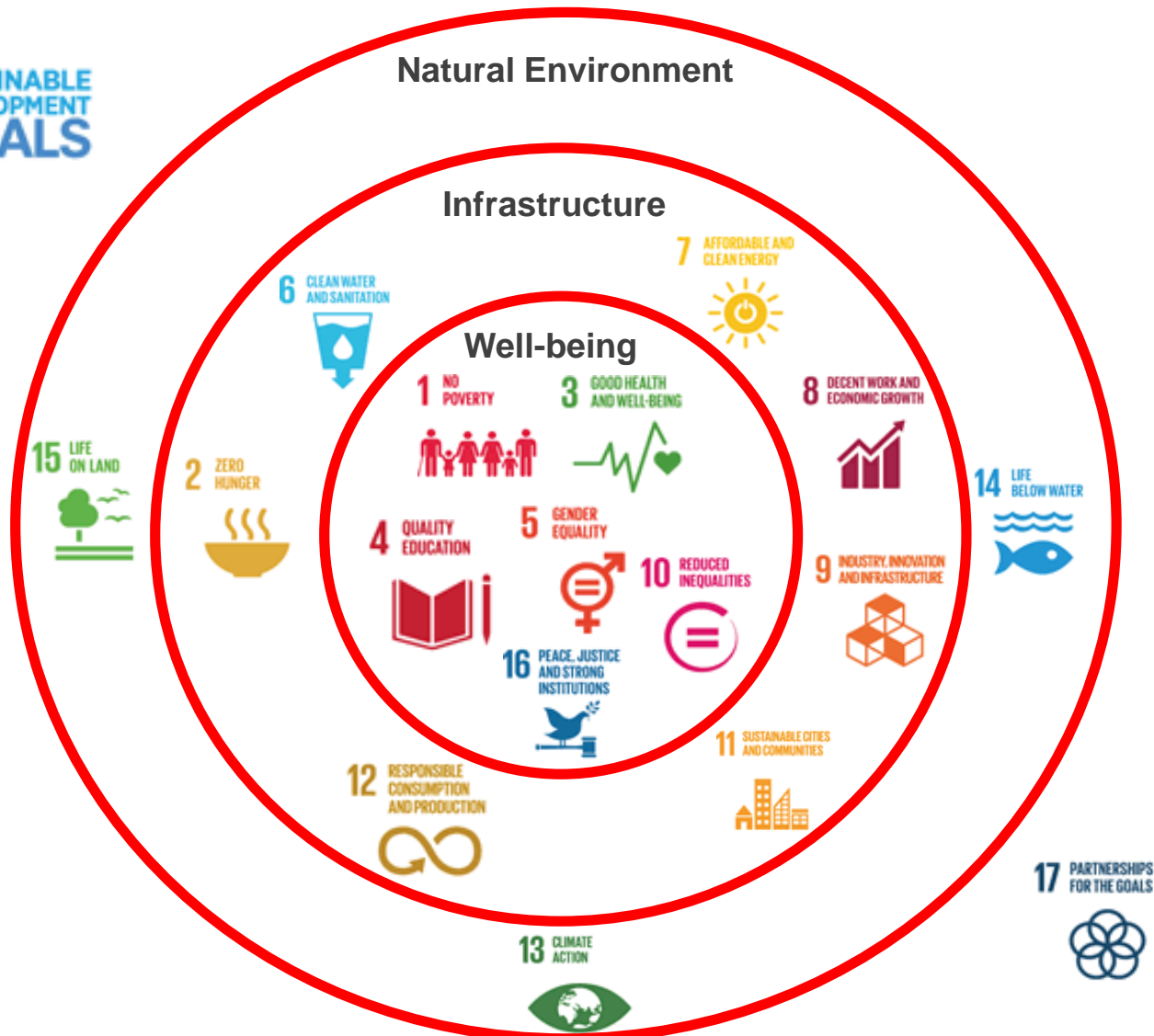
**Panel: Designing Infrastructure for an Uncertain Future**

# **Managing Uncertainties Through System Flexibility**

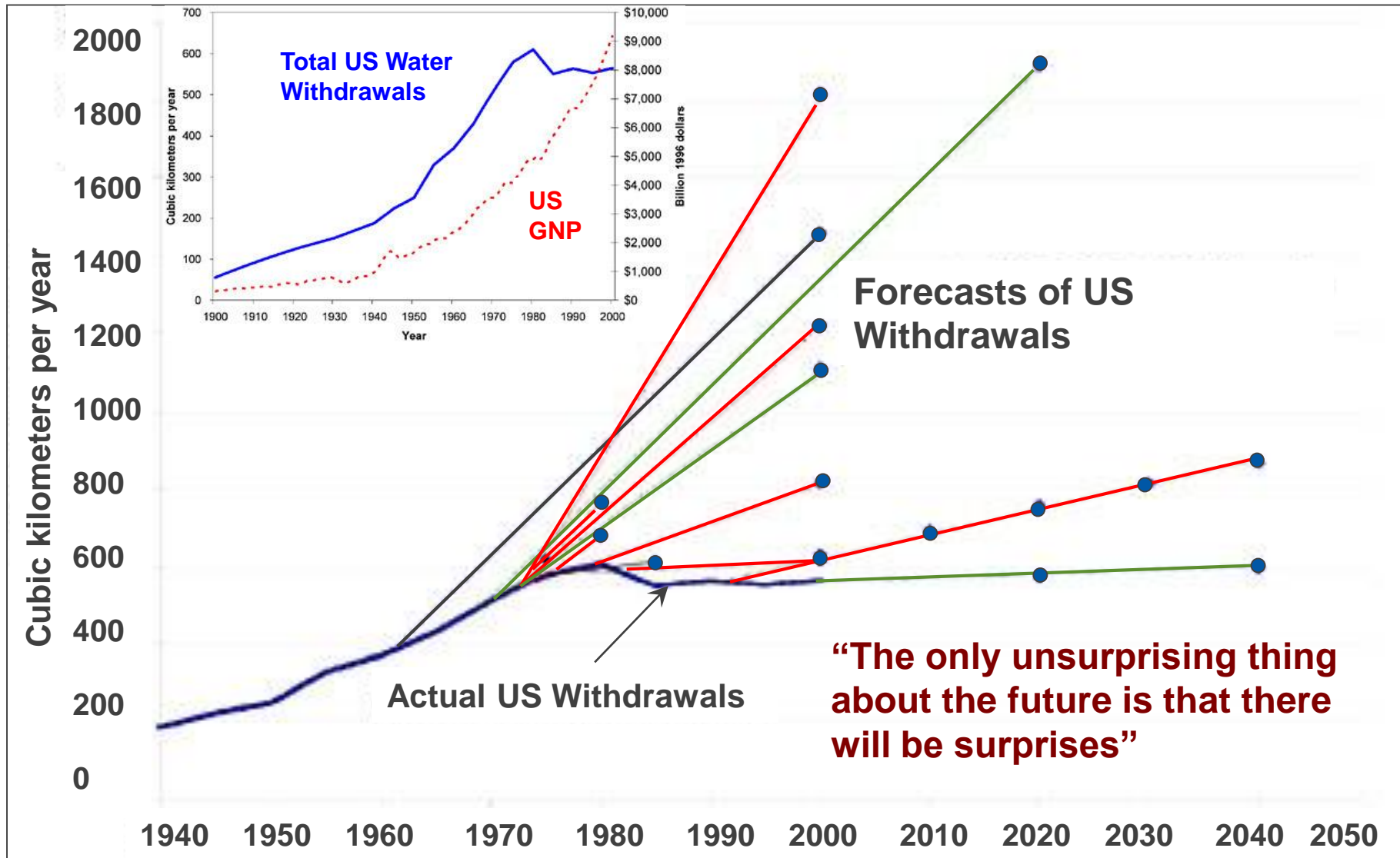
**Afreen Siddiqi, Ph.D.**

Associate Director, Strategic Engineering Research Group, MIT  
Research Scientist, Massachusetts Institute of Technology (MIT)  
Visiting Scholar, Harvard Kennedy School

# Infrastructure is an essential element of sustainable development for societal well-being



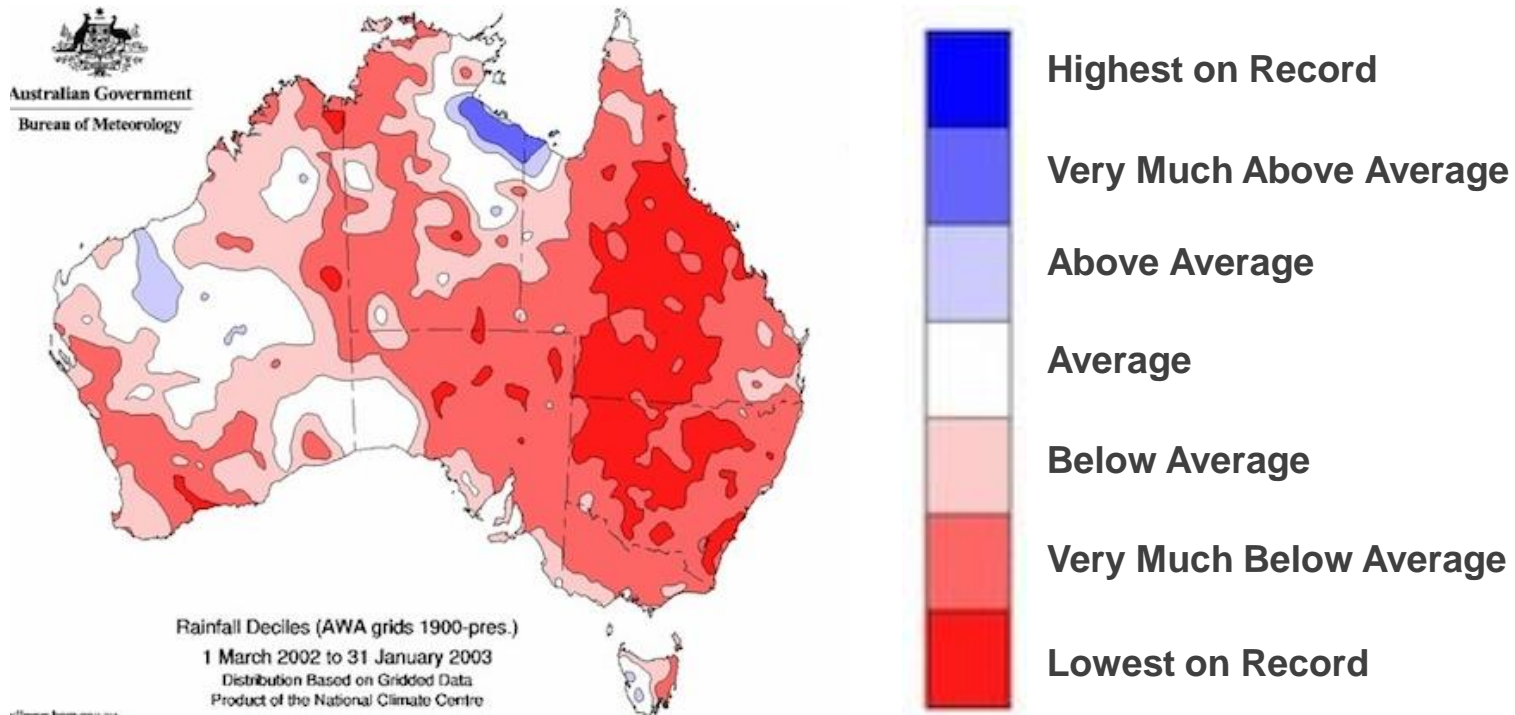
# How do long-term forecasts usually turn out?



# Managing uncertainty with flexibility, systems thinking, and shared valuation

- **Flexible design and real options**
- **Stakeholders engagement for shared valuation**
- **Portfolio (Systems of Systems) planning**

# Infrastructure Planning with Flexibility Under Uncertainty: Managing the Millennium Drought



Sarah Fletcher, Marco Miotti, Jaichander Swaminathan, Magdalena Klemun, Kenneth Strzepek, and **Afreen Siddiqi**, (2017), “Water Supply Infrastructure Planning: Decision-Making Framework to Classify Multiple Uncertainties and Evaluate Flexible Design”, *Journal of Water Resources Planning and Management*, 143(10), 04017061

# Options, Decisions, and Outcomes

## Large desalination plant:

- 150 GL capacity
- AUD 5.7 billion

## Sugarloaf pipeline + Irrigation system upgrade:

- 75 GL av., AUD 1 billion
- Added benefits for environment, irrigators
- Cost diversification through water trading

## Further extension of conservation measures:

- Rainwater tanks
- Stormwater harvesting



**2007**  
**Water Plan:**  
**Desal plant**  
**+**  
**Pipeline**  
**+**  
**Irrigation system upgrade**

**2008, 2009**

**Rainfall increases**

- Storage levels return to normal
- Desalination plant not used

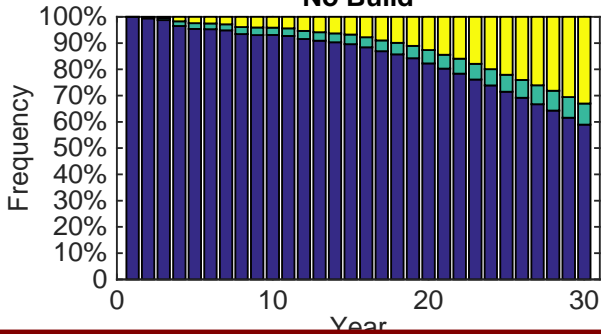
**2010**

**pipeline use restricted to drought years**

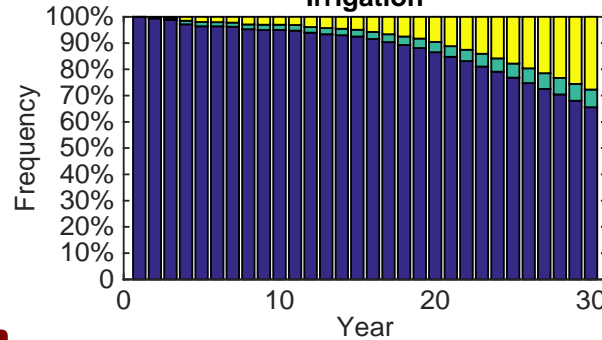
**2018**  
**unused/ minimally used infrastructure**  
**(insurance for future droughts)**

# Risk is a value preference that needs to be chosen through stakeholders engagement

No Build

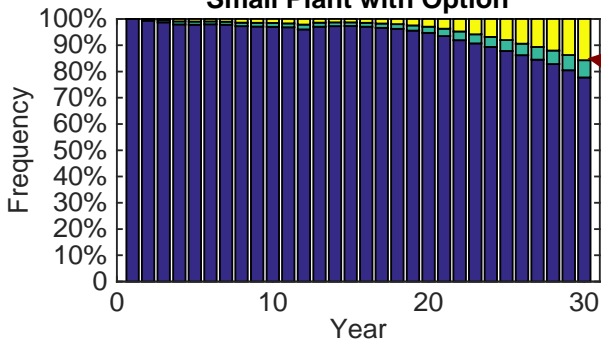


Irrigation

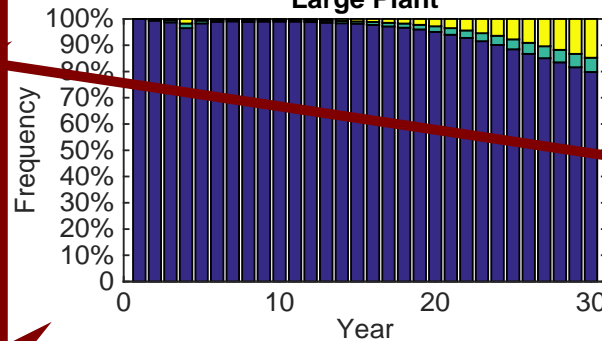


Large annual shortages are concentrated in later years

Small Plant with Option

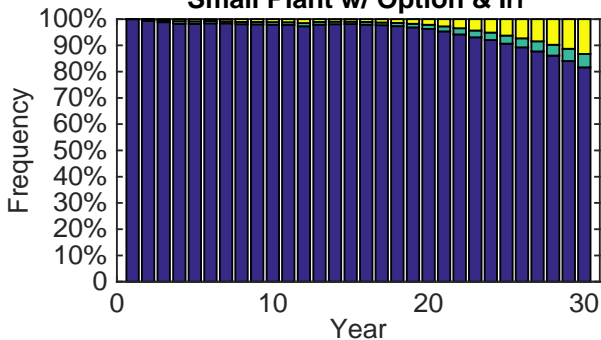


Large Plant

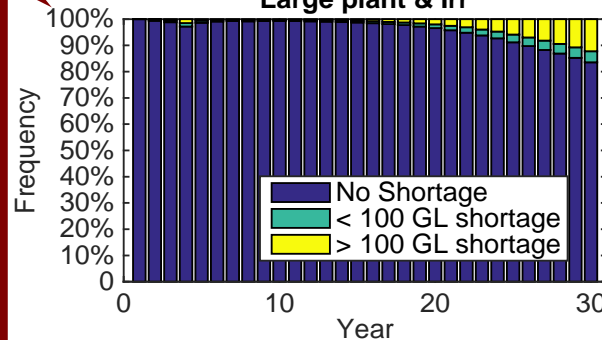


Small flexible plant had similar risks as compared to large plant

Small Plant w/ Option & Irr



Large plant & Irr



Small plant with option (flexibility) to expand was also analyzed

Legend:  
No Shortage (dark blue)  
< 100 GL shortage (teal)  
> 100 GL shortage (yellow)

**THANK YOU!**