Using Annualized Losses to Schedule a Flood Mitigation Capital Improvement Program

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April 23, 2024

Hurricane Matthew
Norfolk, VA
October 9, 2016

https://www.washingtonpost.com/local/matthew-leads-to-power-outages-widespread-flooding-in-se-virginia/2016/10/09/c06c33fc-8e31-11e6-a6a3-d50061aa9fae_ story.html

Case Study

Develop a capital improvement program (CIP) designed to protect a Southeast Virginia wastewater utility's infrastructure against climate change induced flooding

Objectives

How and **when** to protect facilities?

Approach

1. Implement a consistent method to **quantify risk** for planning purposes
2. **Optimize** a project planning **schedule** based on estimates of risk

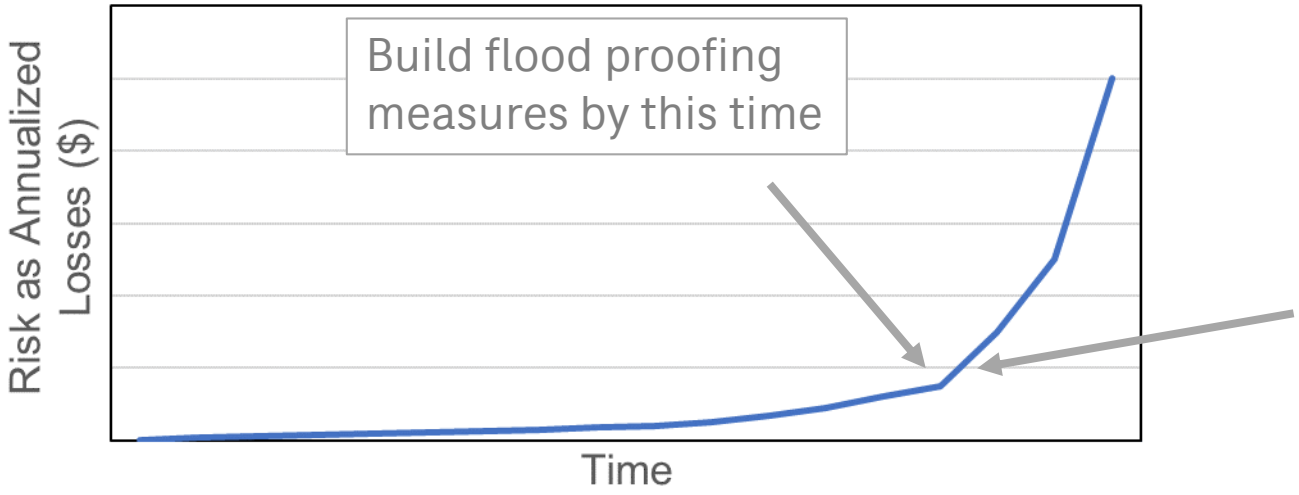
Defining Flood Risk

If floodwaters reached a given elevation, what would it cost us?

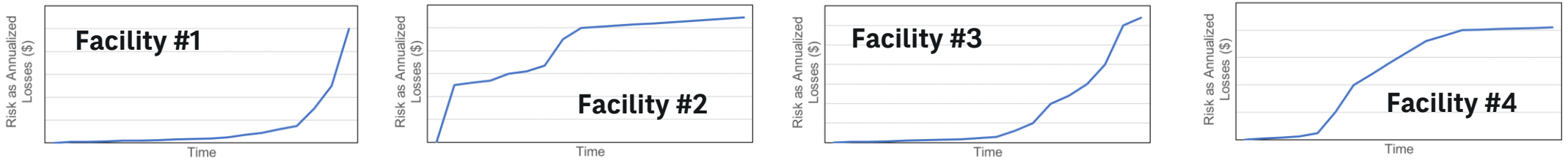
How often will floodwaters reach a given elevation?

CDM Smith Flood Vulnerability Tool

- Calculates **flood risk** based on estimates of **consequences** and **likelihood**
- Simplifies planning for individual facilities.



How do we plan flood proofing for an entire system (60+ facilities)?



Use **multi-objective optimization** to develop a project planning **schedule**

jMetalPy

Python version of the jMetal framework

Optimization Example

How can we optimize our spending on groceries?

Single-objective optimization

Objective:

1. Minimize final cost

Decision Variables:

One optimum solution

Multi-objective optimization

Objectives:

1. Minimize final cost
2. Maximize nutrition
3. Maximize flavor

Decision Variables:

Many “optimum” solutions!

Optimization Formulation

Objectives (Goals)

1) Maximize Benefits

2) Spread Out Costs

3) Minimize Projects/Year

Variables ("Knobs")

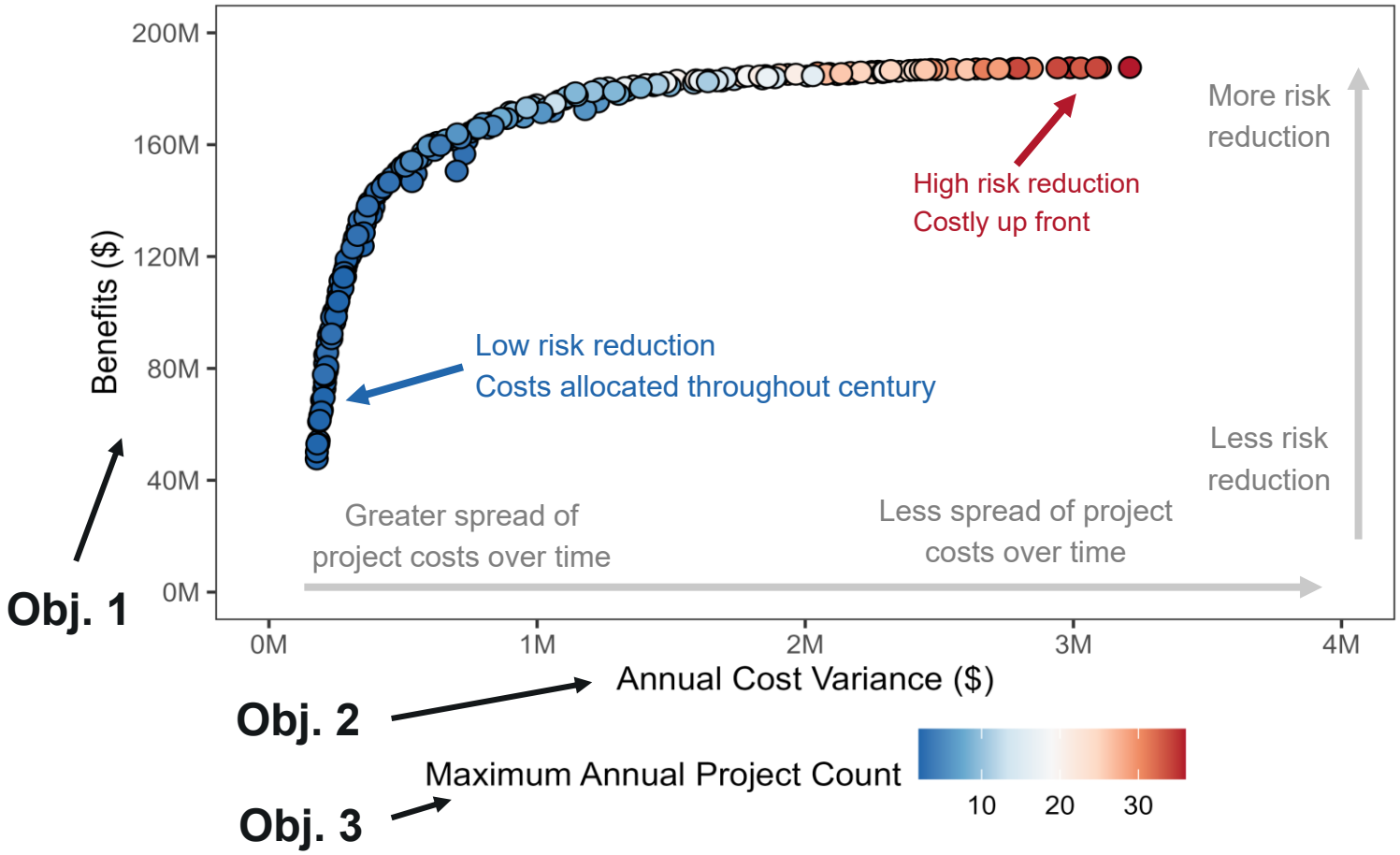
Project start years for each (60+) facility

Solution

Project schedule (CIP) that includes project start years for all facilities

Optimization Results

- Results may be displayed as “pareto front”
- Individual points represent different **CIP schedules**
- Visualize **tradeoffs** between objectives



Optimization Results

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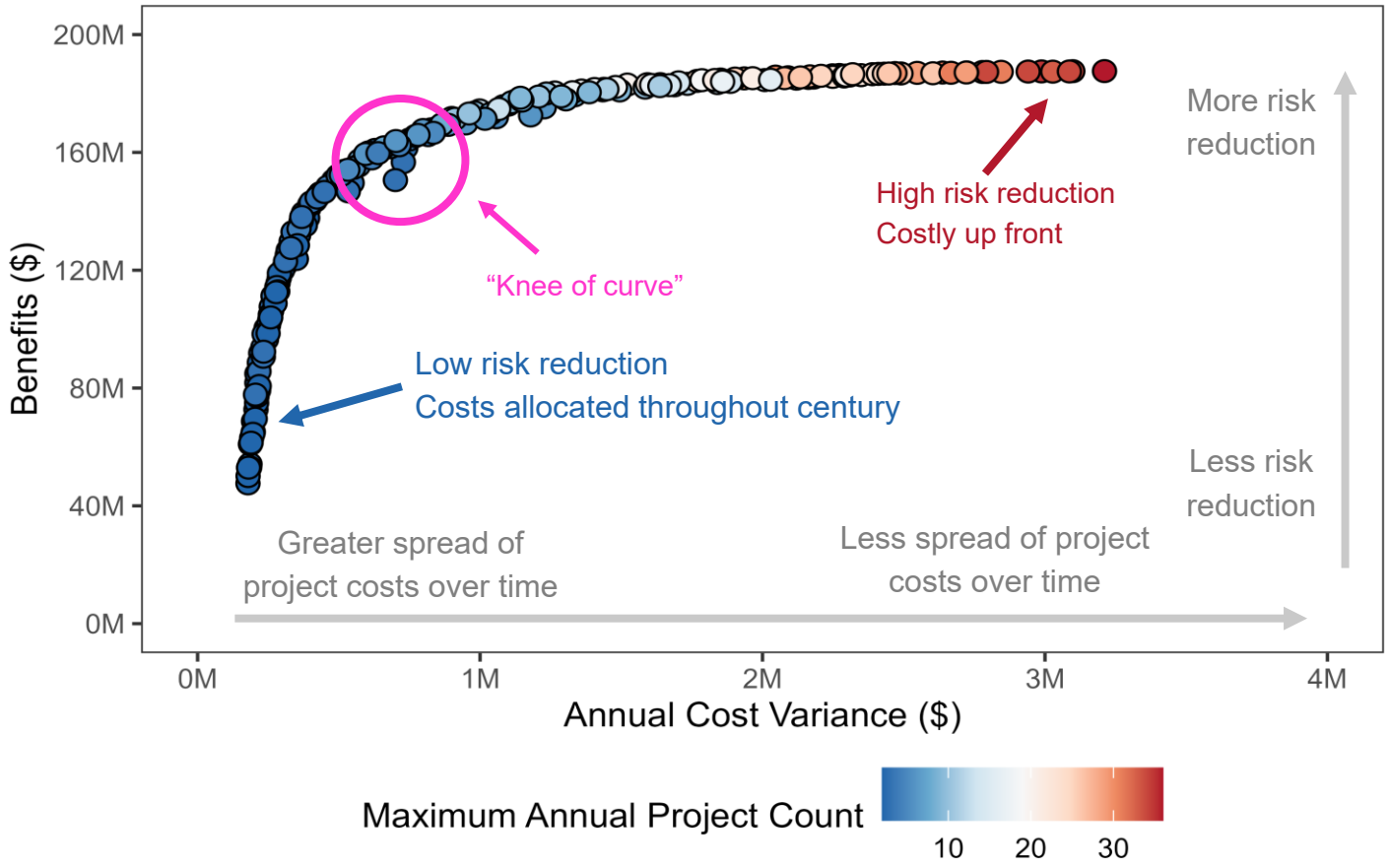
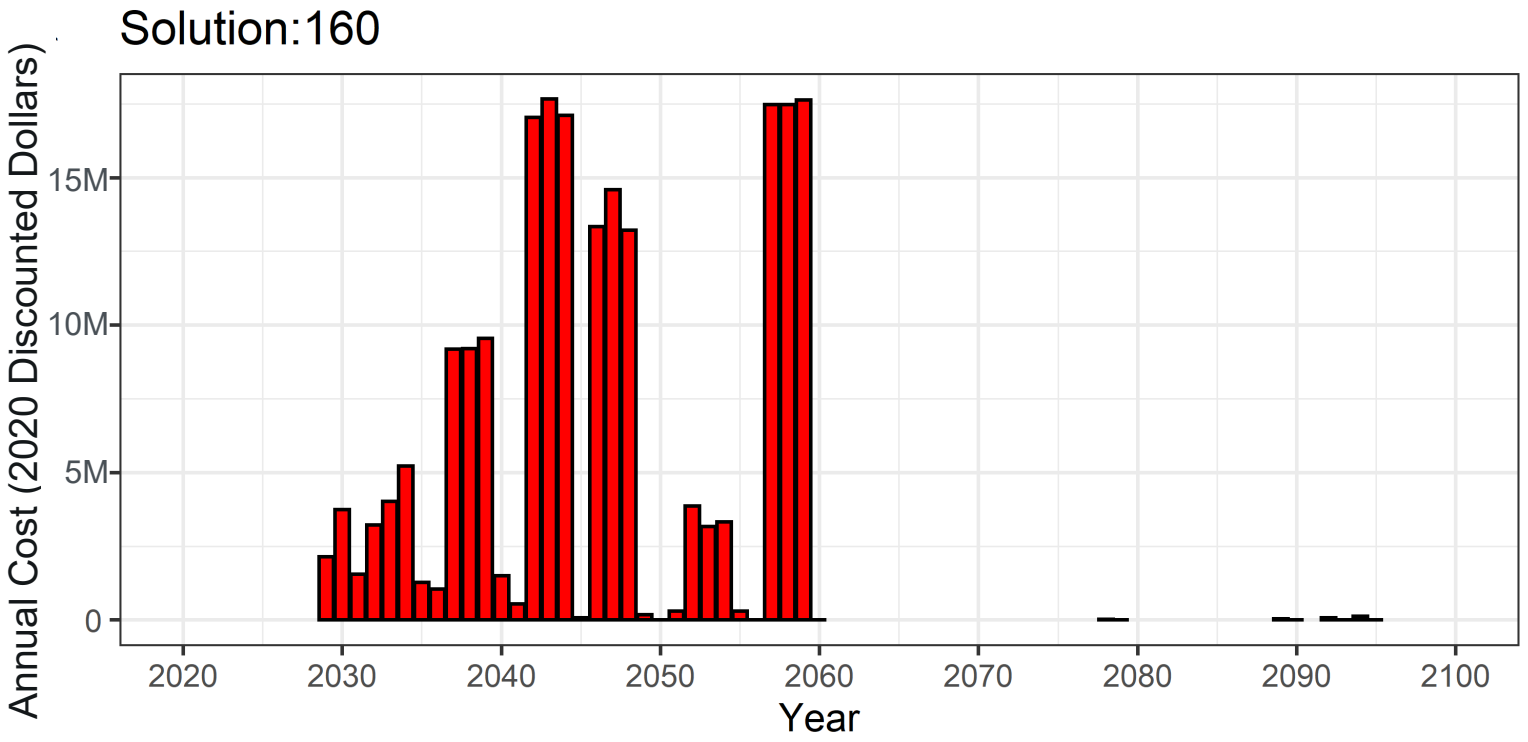
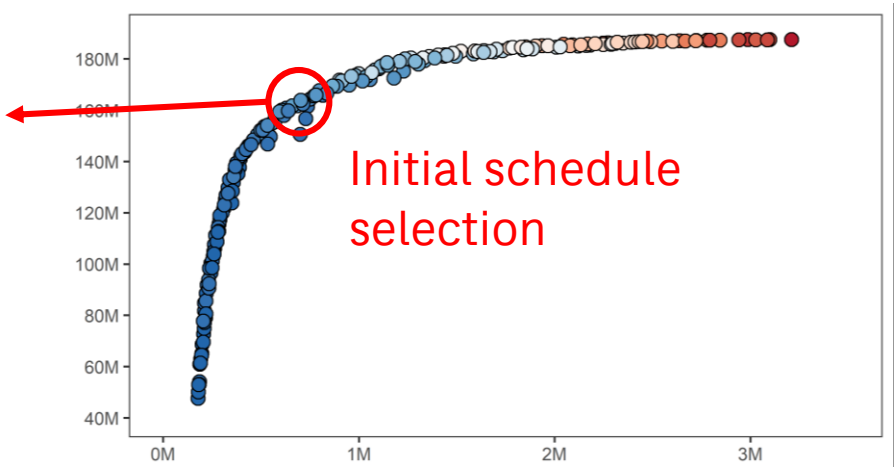
- Diminishing returns in total benefits after “knee of curve.”



Draft Schedule

- An initial CIP schedule can be selected directly from optimization results.
- Further refinements made to schedule, as necessary.





Conclusions

- Evaluated **flood risk** by facility using a flood vulnerability tool
- Quantified tradeoffs between risk reduction and project spending using **multi-objective optimization**
- Established a draft **capital improvement program** schedule for 60+ facilities within a wastewater utility

Questions?