Economic Analysis of a Basic and Applied Research Agenda: Strategies for Prioritization

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Institute of Medicine Roundtable on Environmental Health Sciences, Research and Medicine

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I will be Taking the Charge Seriously

- Economics – accept a risk-based approach: risk analysis, communication and management
- Basis and applied – more of a tactic than a strategy or agenda, per se; builds from discussions with actual decisionmakers (NYC)
- Prioritization research topics – sorting through the litany of issues and working through the time dimension
- Research – design to support decisions rather than serendipity
- Focus on adaptation but include sensitivity to mitigation

Context: Major Lessons from the Fourth Assessment Report (2007)

- Adaptation is unavoidable because the planet would be committed to more warming even if emissions of greenhouse gases were halted today (Kevin yesterday).
- **Responding to climate change involves an *iterative risk management process* that includes *both adaptation and mitigation* and takes into account climate change *damages, co-benefits*, sustainability, equity, and attitudes to risk.**

Underlying Themes for Thinking Practically about Applied Research into Responding

- Uncertainty is ubiquitous – risk is what matters
- Risk is Probability times Consequence
- Risk expressed in terms of vulnerabilities (not just exposures) is the common denominator even if the metrics are not the same
- Risk management is the most appropriate policy lens and can provide methods for prioritization research initiatives
- Focusing on risk broadens the perspective beyond “high confidence” vulnerabilities and can incorporate the truth that timing is important.

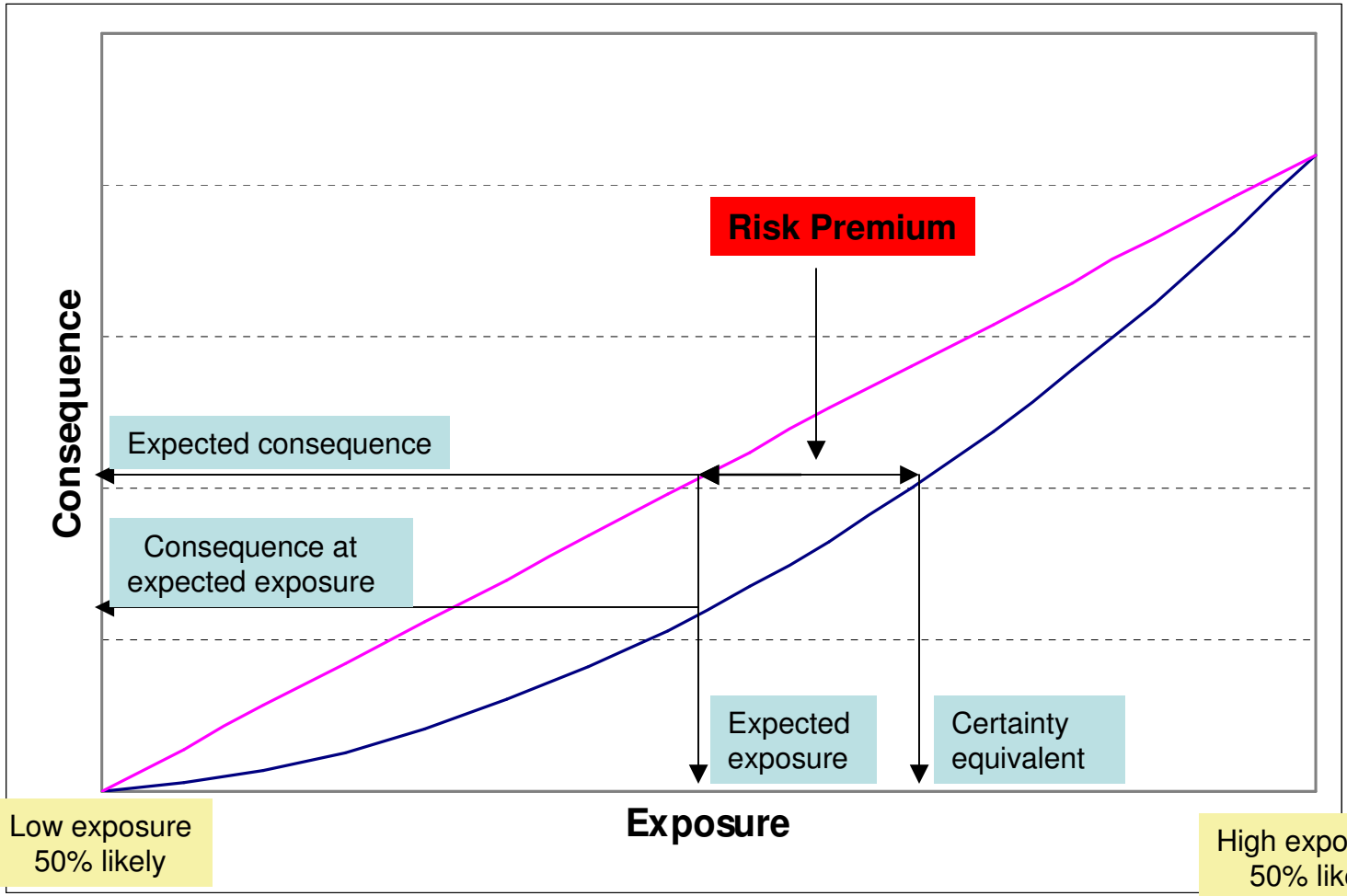
Some Fundamental Concepts

- When we know a lot about both probability *and* consequence, “expected value” of risky outcomes can be used to communicate information to decision-makers – this is approach used in most benefit-cost analyses.
- Risk management approaches are useful when we need to look at probabilities and consequences in greater detail – especially when consequences are non-linear with respect to exposure and/or exposure is non-linear with respect to the driving forces.
- Risk management uncovers the economic efficiency of diversification and insurance.

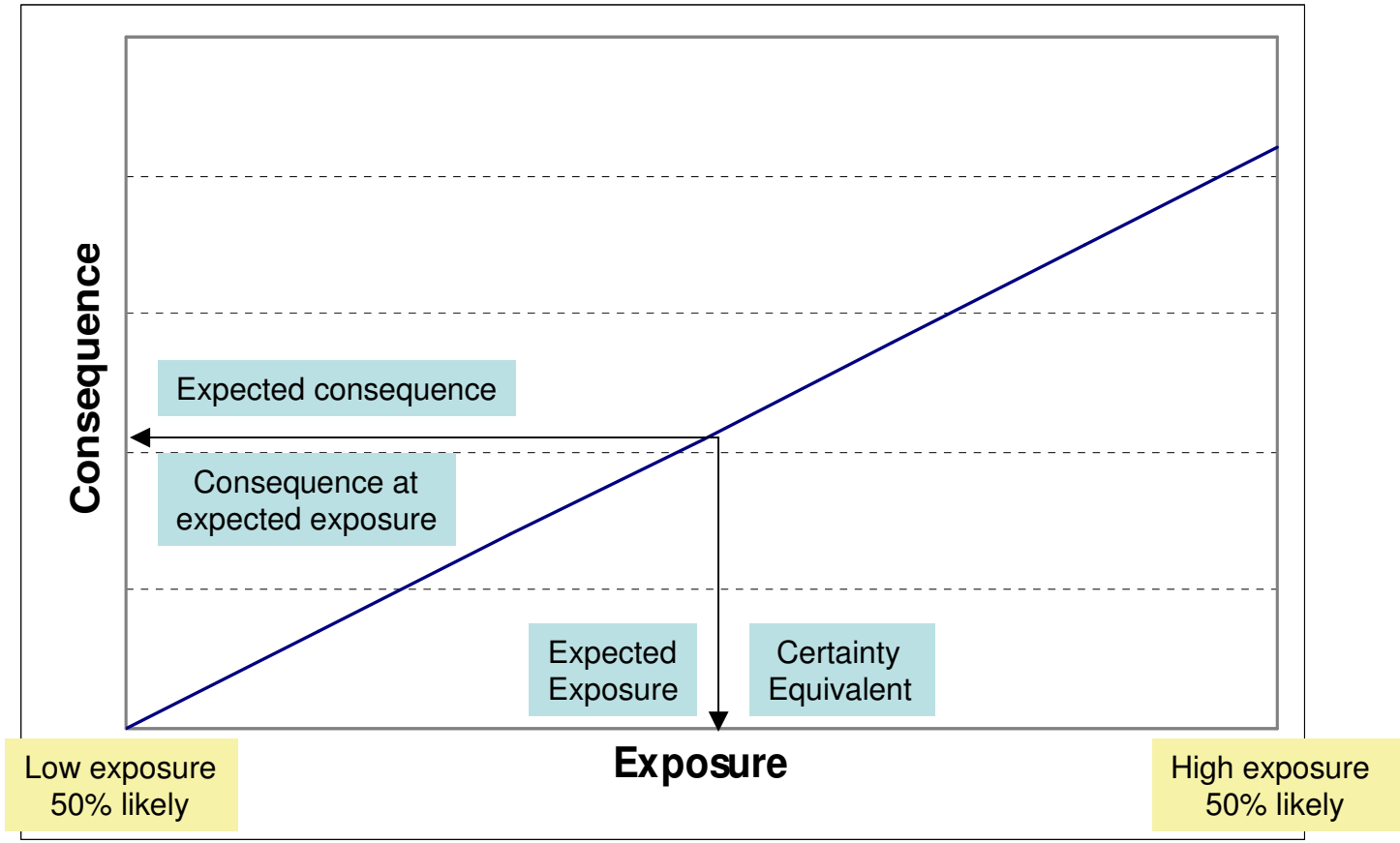
Comparative Strengths of "Risk Management" Approach

- Risk management approaches are particularly helpful when:
  - There is substantial uncertainty (temporal, spatial, or otherwise) even about the probabilities of events.
  - Actors are risk-averse – so simple expected value calculations and/or representations of "most-likely" scenarios do not adequately inform appropriate decisions.
  - There are fundamental uncertainties that will simply not be resolved in a timely fashion (e.g., climate sensitivity, socio-economic site specific development pathways, etc…).

An Illustration: Nonlinearity and Aversion to Risk



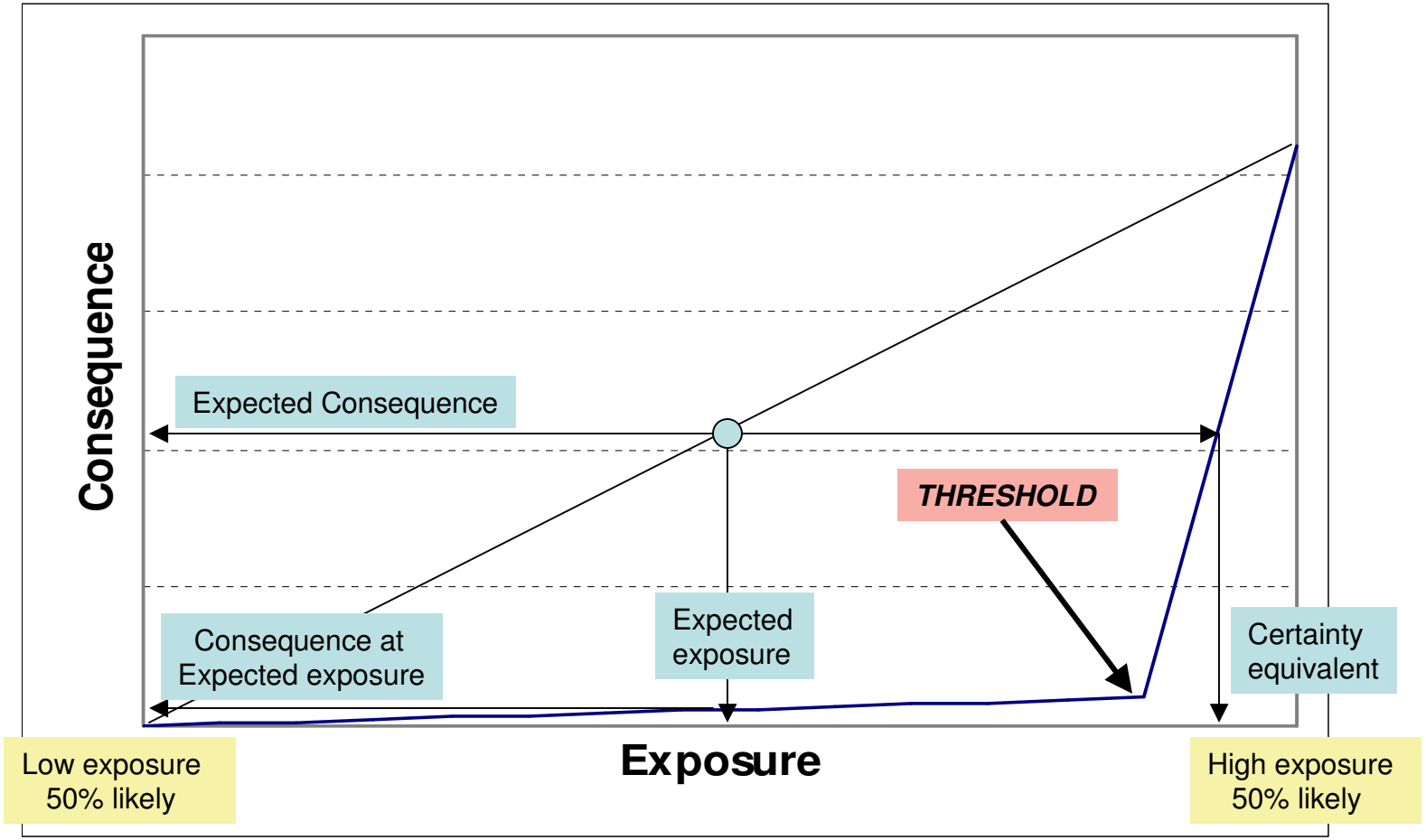
Another Illustration: Linearity and Risk Neutrality



Interpreting the Graphs

- Especially useful when consequences are measured in specific and malleable units (like currency).
- Certainty equivalence and the associated risk premia are then appropriate comparative metrics that support estimates of the value of information (research results).
- The efficacy of adaptation and/or mitigation to alter relative likelihoods and/or ameliorate consequences (reduce harm or enlarge benefits by changing exposures and/or sensitivities).

Identifying Thresholds can be Productive when Units are not particularly Malleable



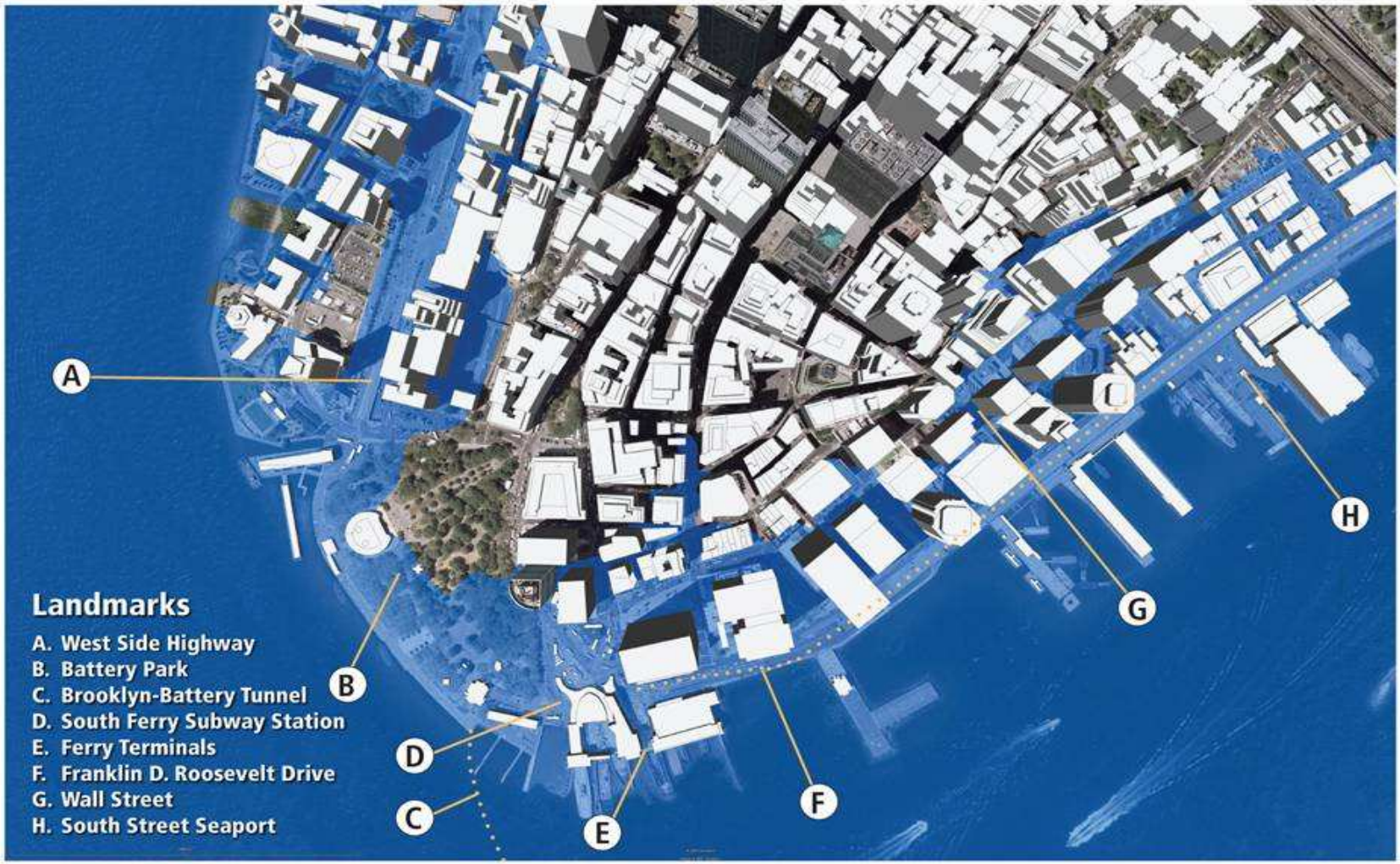
Identifying Thresholds can Simplify the Application of a Risk-Management Approach

- Estimate chances of crossing a “high consequence” threshold under alternative scenarios.
- Examples of relevant climate-related thresholds include:
  - Temperature thresholds
  - Storm event intensities and/or return-times
  - Drought
  - *All and more are drivers of health risk*
- Key outcomes: evaluate how climate change alters the risk of a clearly definable event occurring in any given period of time regardless of how it is defined.

A "Real World" Example

- The 100-year flood in New York City:
  - It is difficult to characterize all of the consequences of the event.
  - It is possible to think rigorously about probability of this event.
  - Key questions involve how and when to invest in adaptive measures (building sea walls, enhancing pumping capacities, changing building codes).

Risk Management Example – NYC and the 100-Year Flood



www.climatechoices.org/ne/

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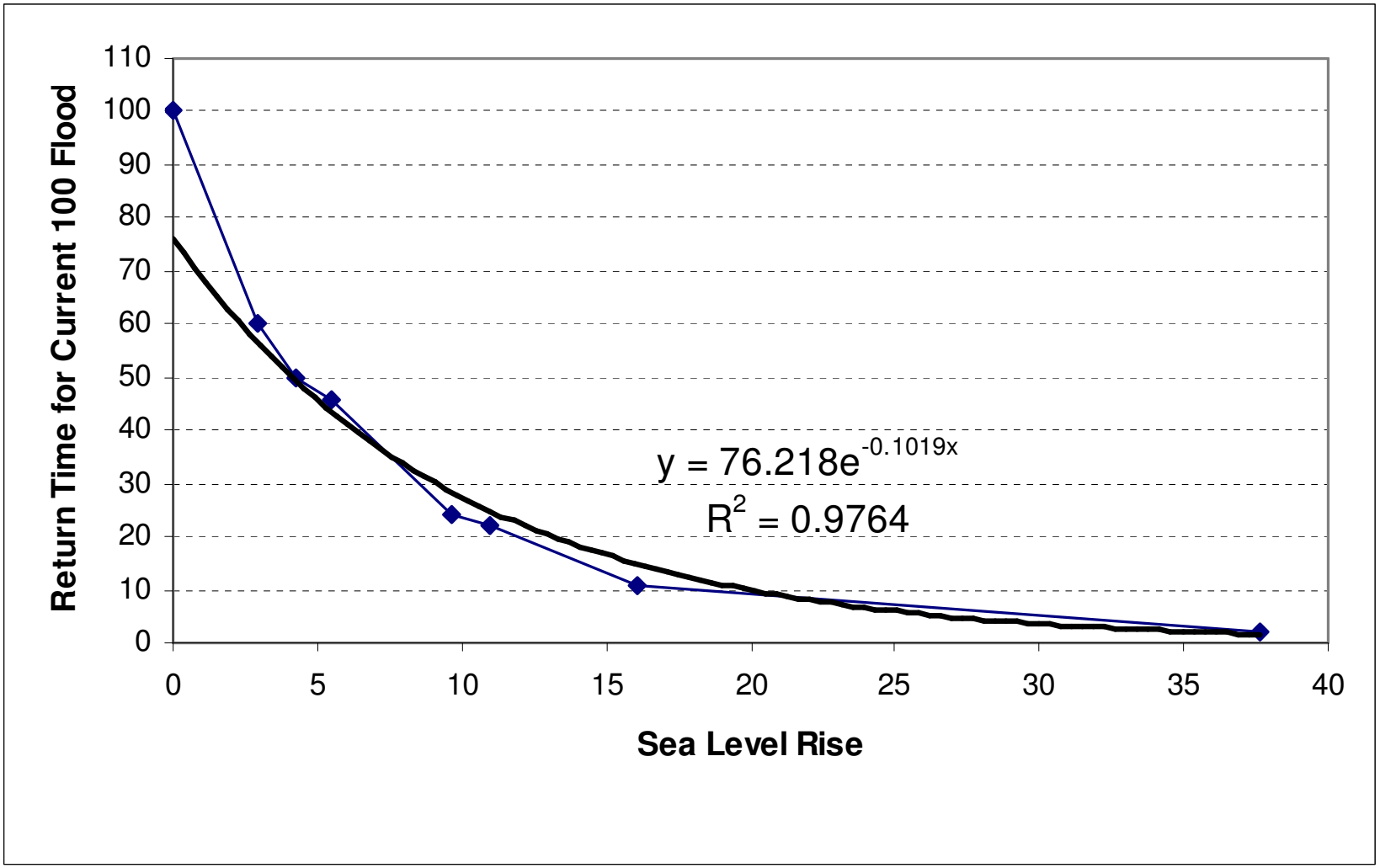

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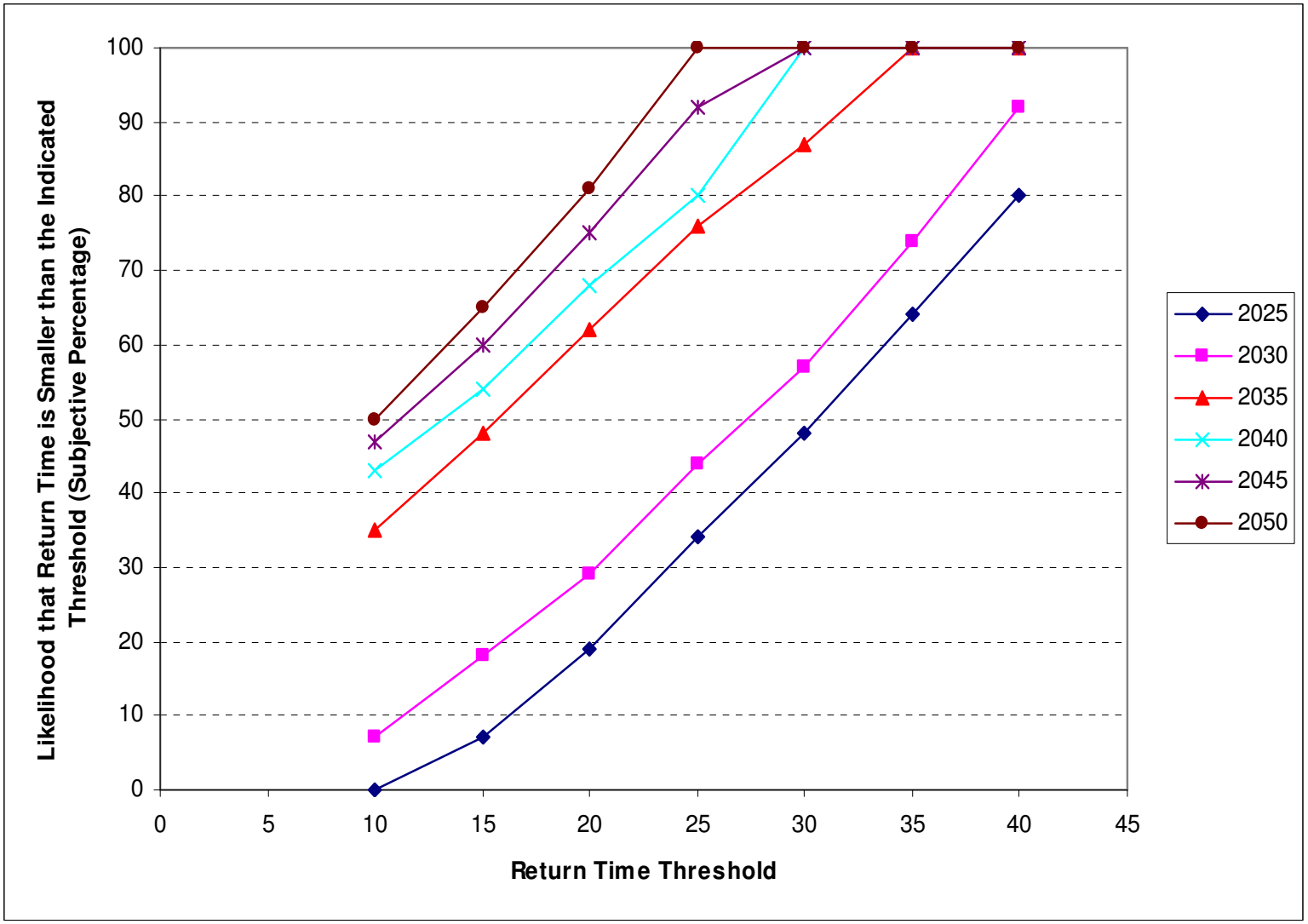


Risk Profiles…

- show the need for adaptation over time
- show the need for contemplating tolerable risk levels
- can show sensitivities of risk to mitigation – the value of mitigation
- are unitless, so they can be compared across multiple metrics and therefore across multiple manifestations of climate change.
- require enormous amounts of information. What if it is not available?

A Prioritization Method from NYC

Identify at-risk infrastructure	Conduct an inventory of critical infrastructure using the NPCC's Climate Risk Information to determine which assets and operations could be at risk from climate change.
Rank the magnitude and likelihood of impacts on critical infrastructure	Using the qualitative definitions included in the Prioritization Framework, categorize: • the potential magnitude (insignificant/low; moderate; high) of the climate change impact and • the likelihood (not relevant or insignificant; low; moderate; high; certain/nearly certain) that it will occur
Determine location on the Risk Matrix (RM)	Using the categories assigned in Step 2, determine the climate change impacts' location on the Risk Matrix to identify infrastructure for which adaptation strategies should be developed
Draft adaptation strategies	Leverage NPCC tools and internal expertise to develop adaptation strategies for prioritized risks, including but not limited to maintenance and operations; retrofits; investments in new infrastructure; and policy changes.
Determine location of strategies on the Prioritization Matrix (PM)	Assess adaptation strategies and determine the location of strategies on the Prioritization Matrix to create an implementation plan.

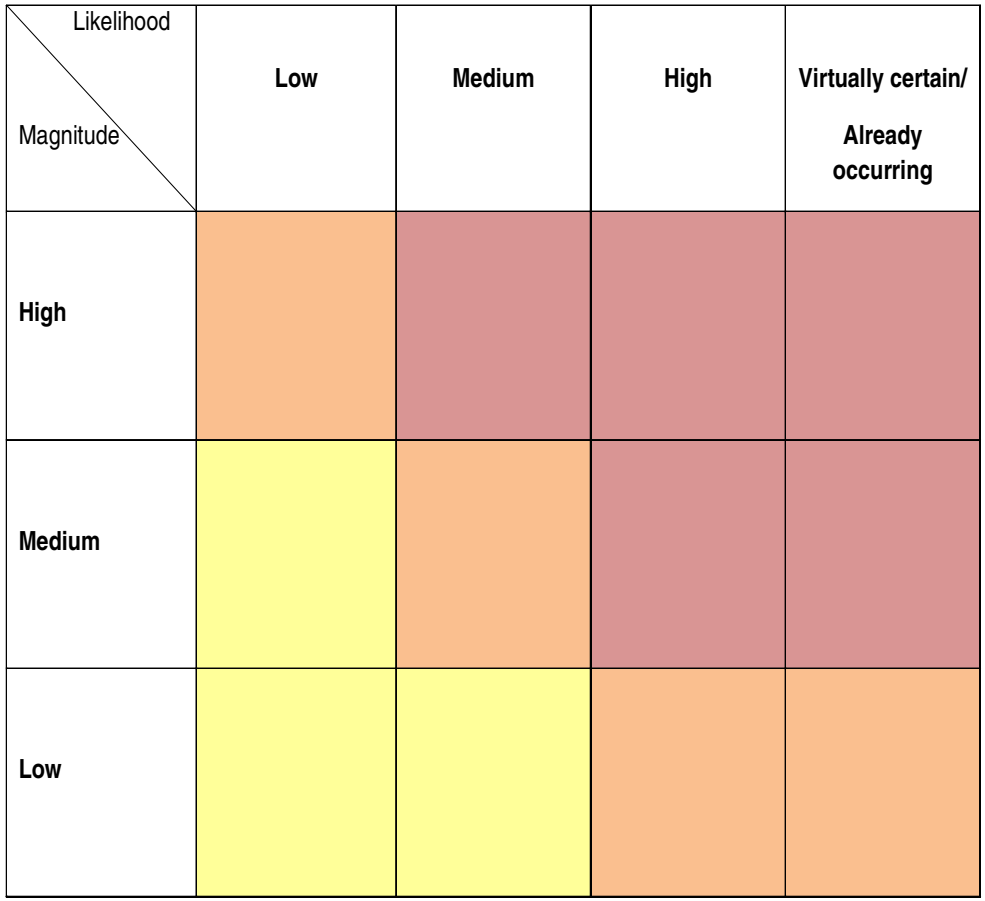
Risk is *Likelihood* times Consequence

	Definition
Virtually certain/ already occurring	Nearly certain likelihood of a climate variable impact occurring over the useful life of the infrastructure (i.e. increased temperatures between 4 and 7.5 F by the end of the century will increase stress on HVAC systems) and/or variable may already be impacting infrastructure (i.e. subways flood during heavy rains)
High likelihood	High likelihood of the impact occurring over the useful life of the infrastructure.
Moderate likelihood	Moderate likelihood, with some uncertainty remaining, that the impact will occur over the useful life of the infrastructure.
Low likelihood	Low likelihood of the impact occurring over the useful life of the infrastructure.

Risk is Likelihood **times** ***Consequence***

	Low	Medium	High
Worker Safety	• No employees put in danger	• Some danger to employees may exist	• Employees put in danger
Medical/ Injuries	• No to small number of potential injuries • No long-term health impacts	• Moderate number of injuries • Potential for fatalities • Some long-term health impacts	• Significant number of injuries • Significant fatalities • Significant long-term health impacts
City-wide Economy	• Insignificant impact on NYC's economy	• Localized or sector-specific impacts on NYC's economy	• Significant impact on NYC's economy or on many sectors of NYC's economy
Clean-up Costs	• No or minor clean up costs	• Moderate clean up costs, easily absorbed	• Significant clean up costs
Price of Service	• No impact on price of services	• Some incremental costs associated with services	• Significant incremental costs associated with utilities/services

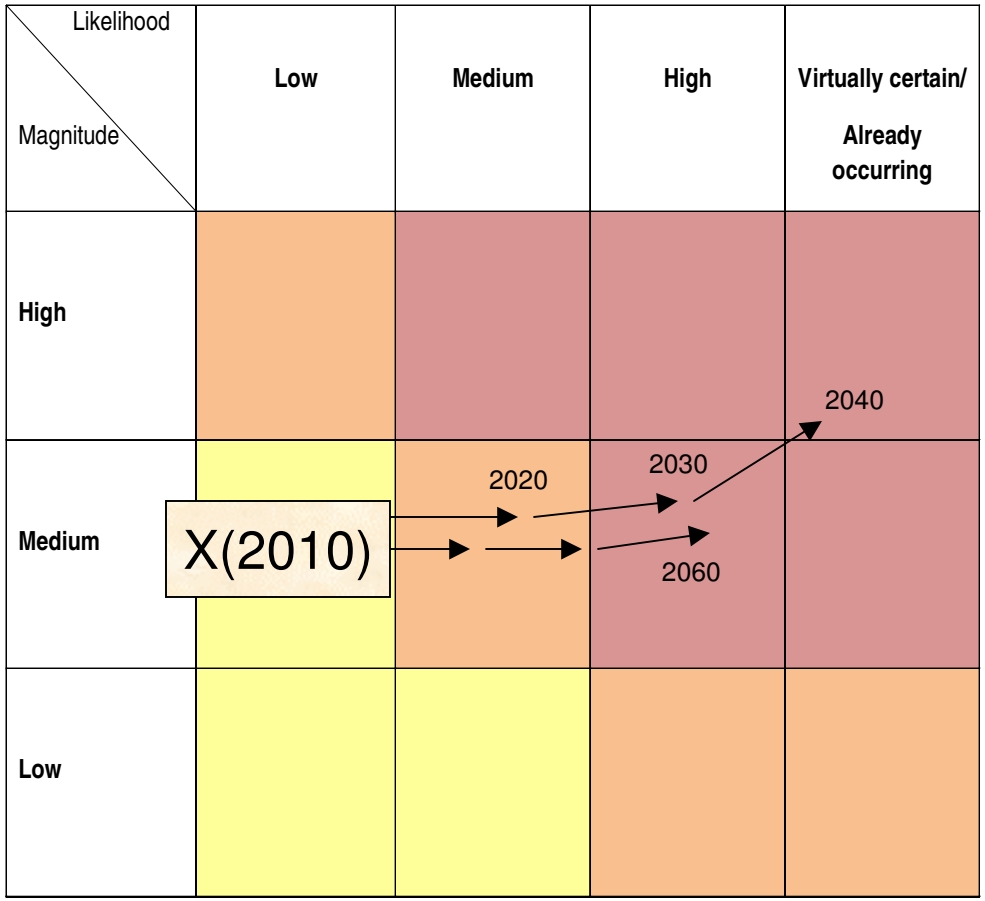
An Operational Risk Matrix to Support Comparisons Across Multiple Vulnerabilities



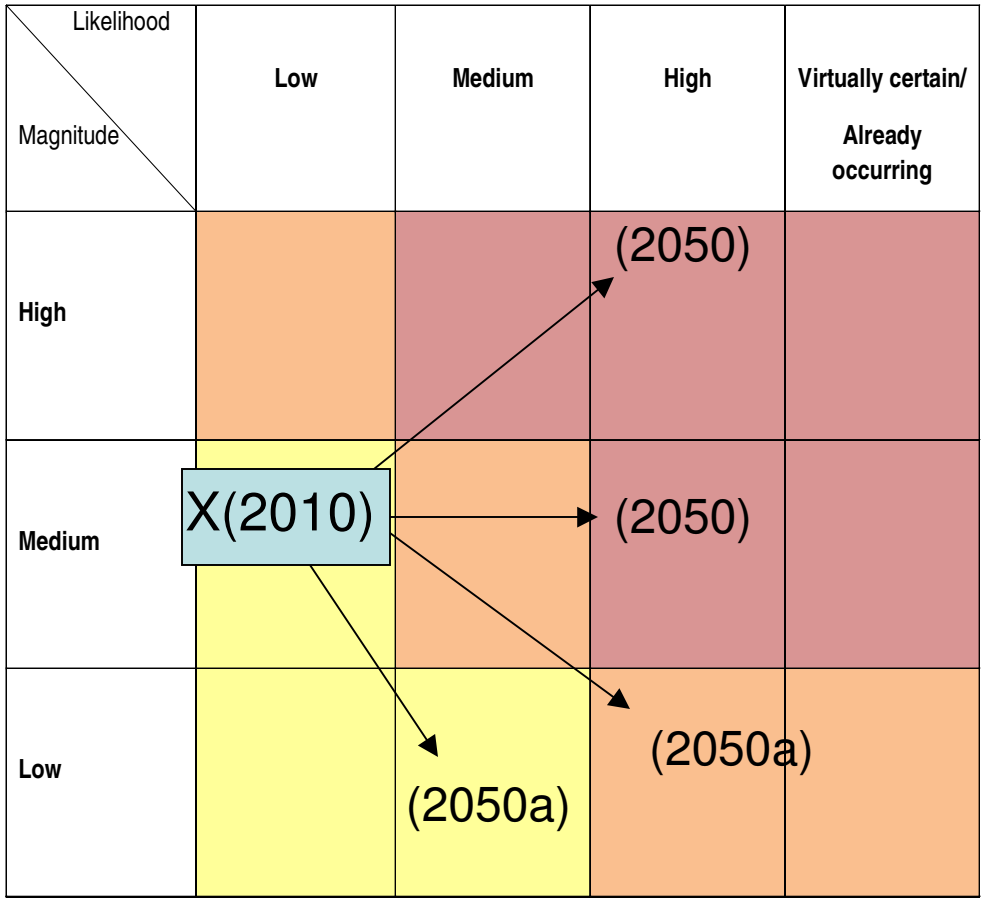
Locating Multiple Vulnerabilities in a Risk Matrix for a Point in Time

Likelihood / Magnitude	Low	Medium	High	Virtually certain/ Already occurring
High			Z	
Medium	X			
Low		Y		

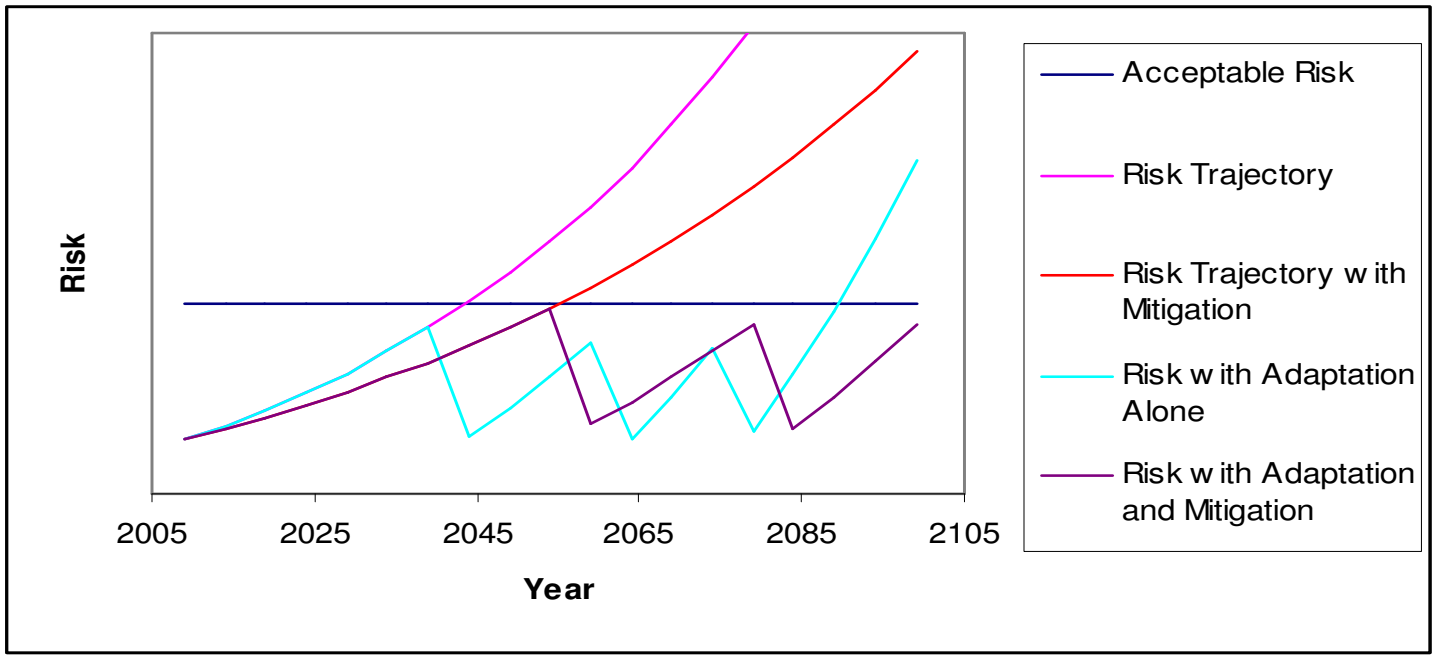
Tracking Risk over Time
Alternative Climate Futures



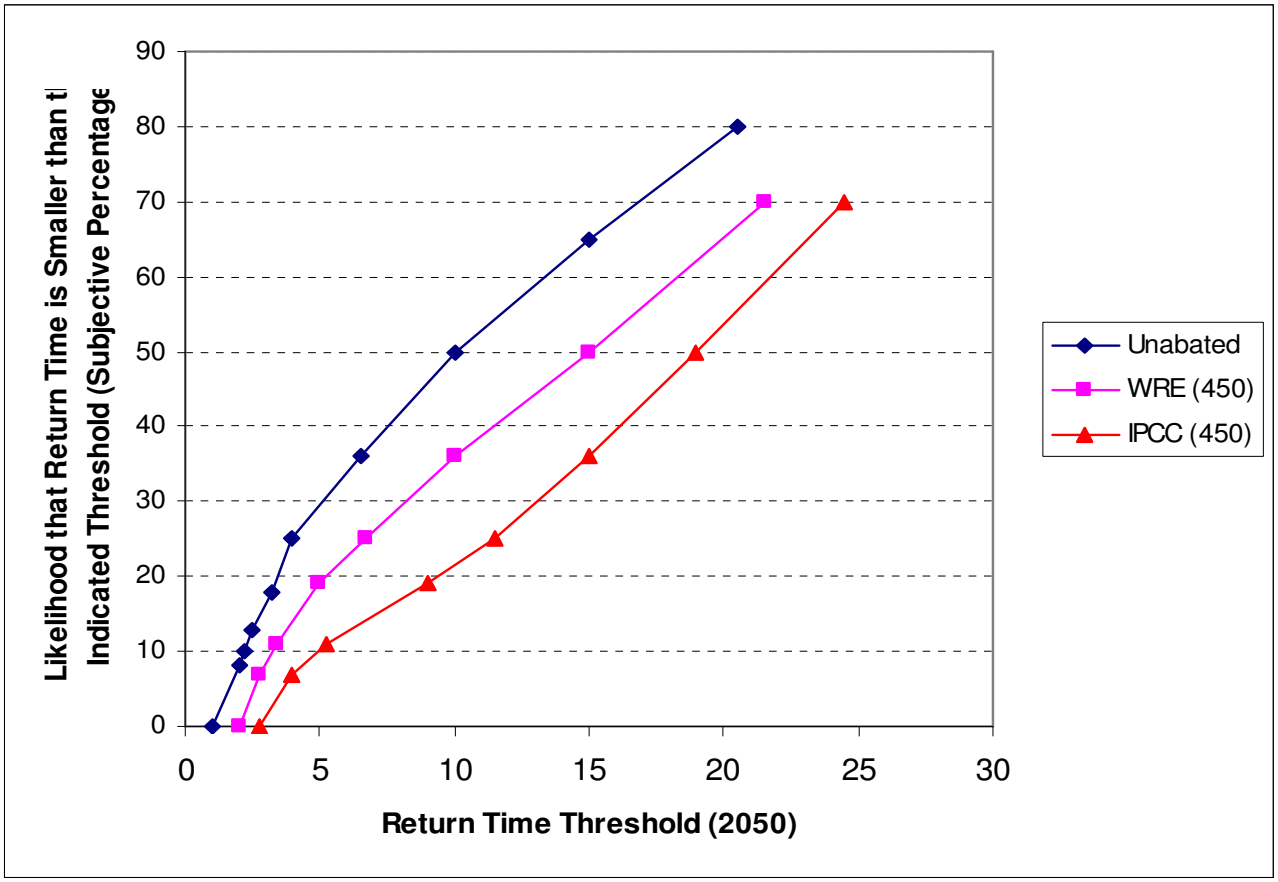
Tracking Exposure, Sensitivity, and Adaptation over Time



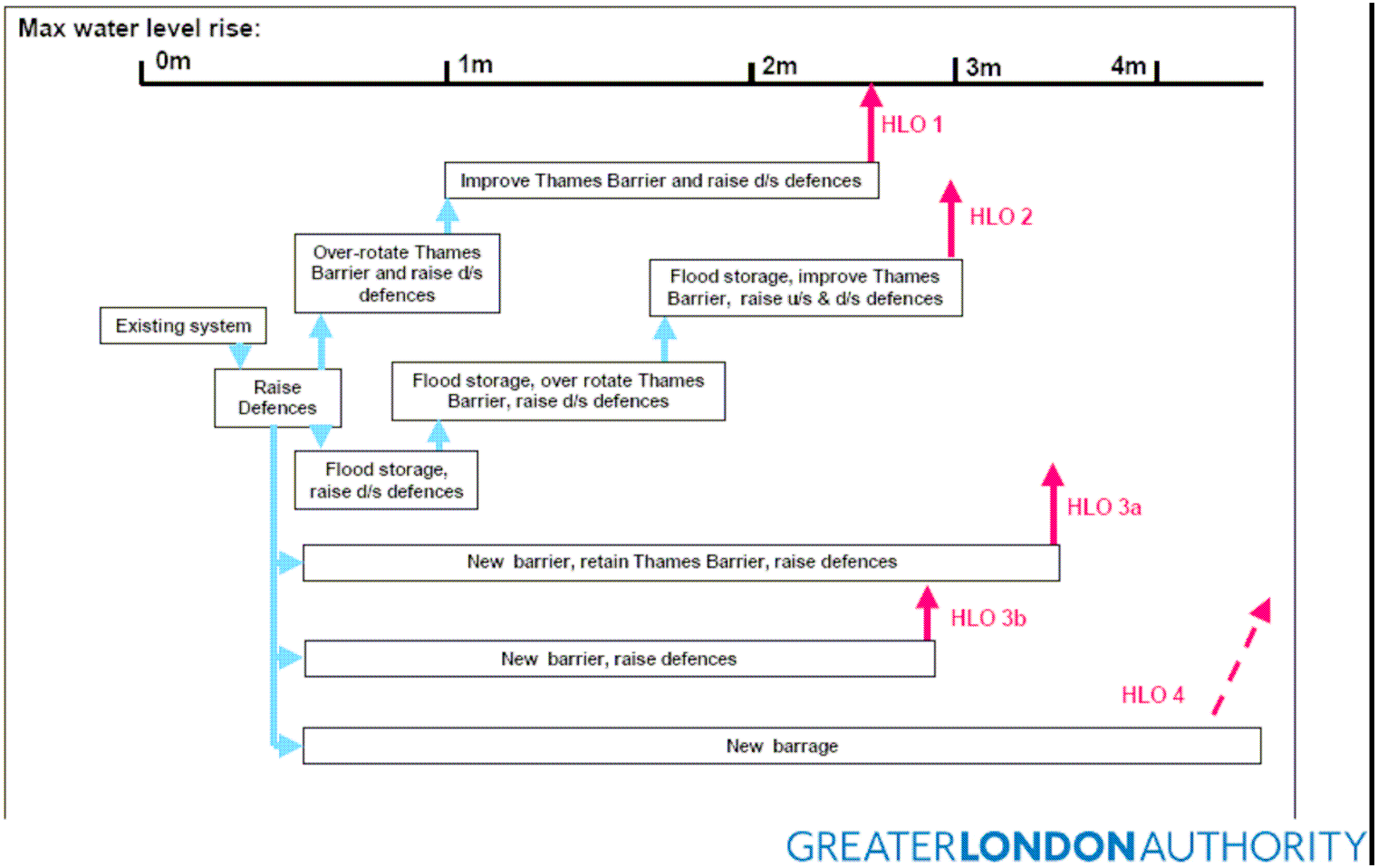
Something Iterative over Time
Flexibility is generally Desirable



Calibration to the NYC Example: Noting the Value of Mitigation



London's on the Ground Version of Iterative Decisions

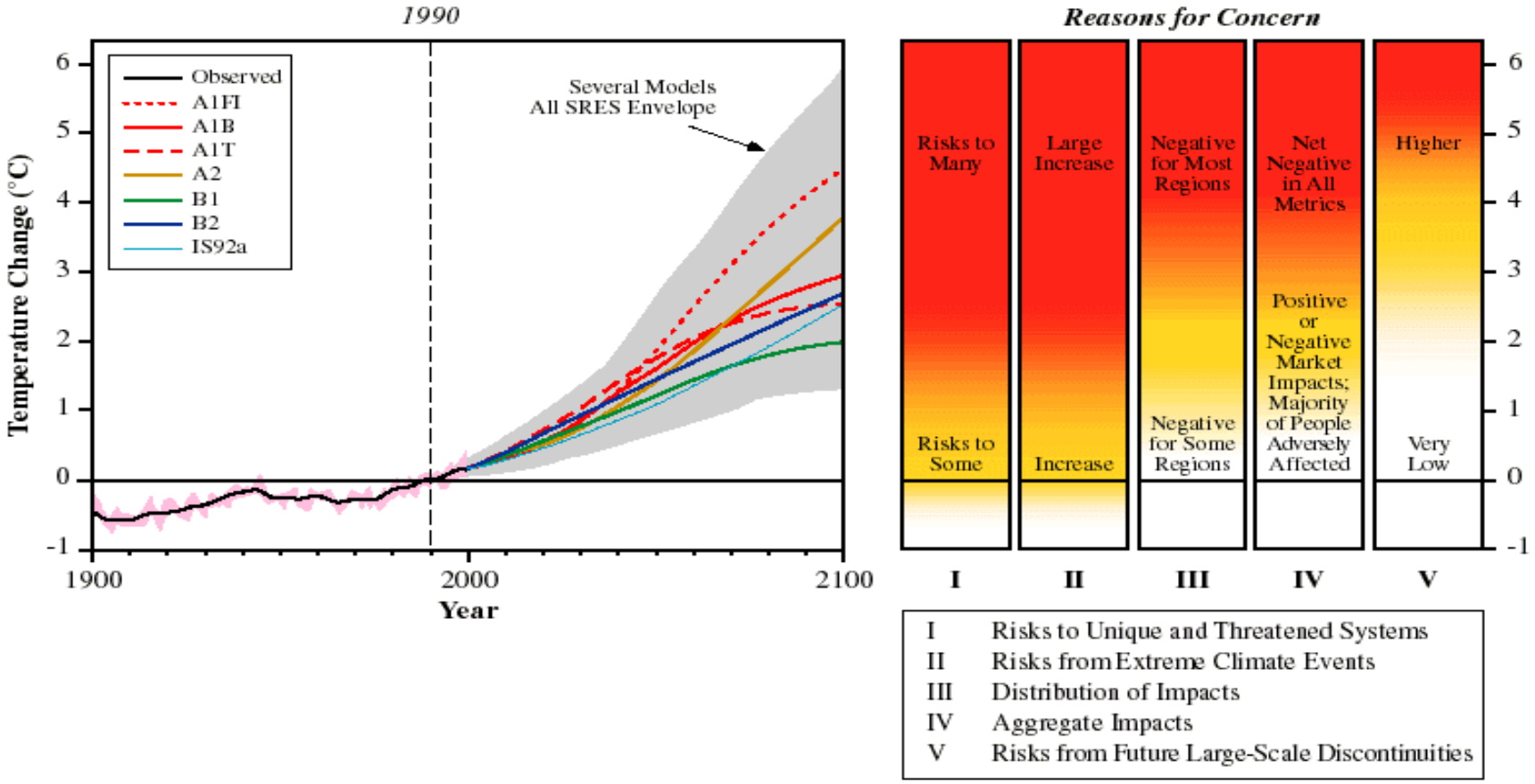


GREATERLONDONAUTHORITY

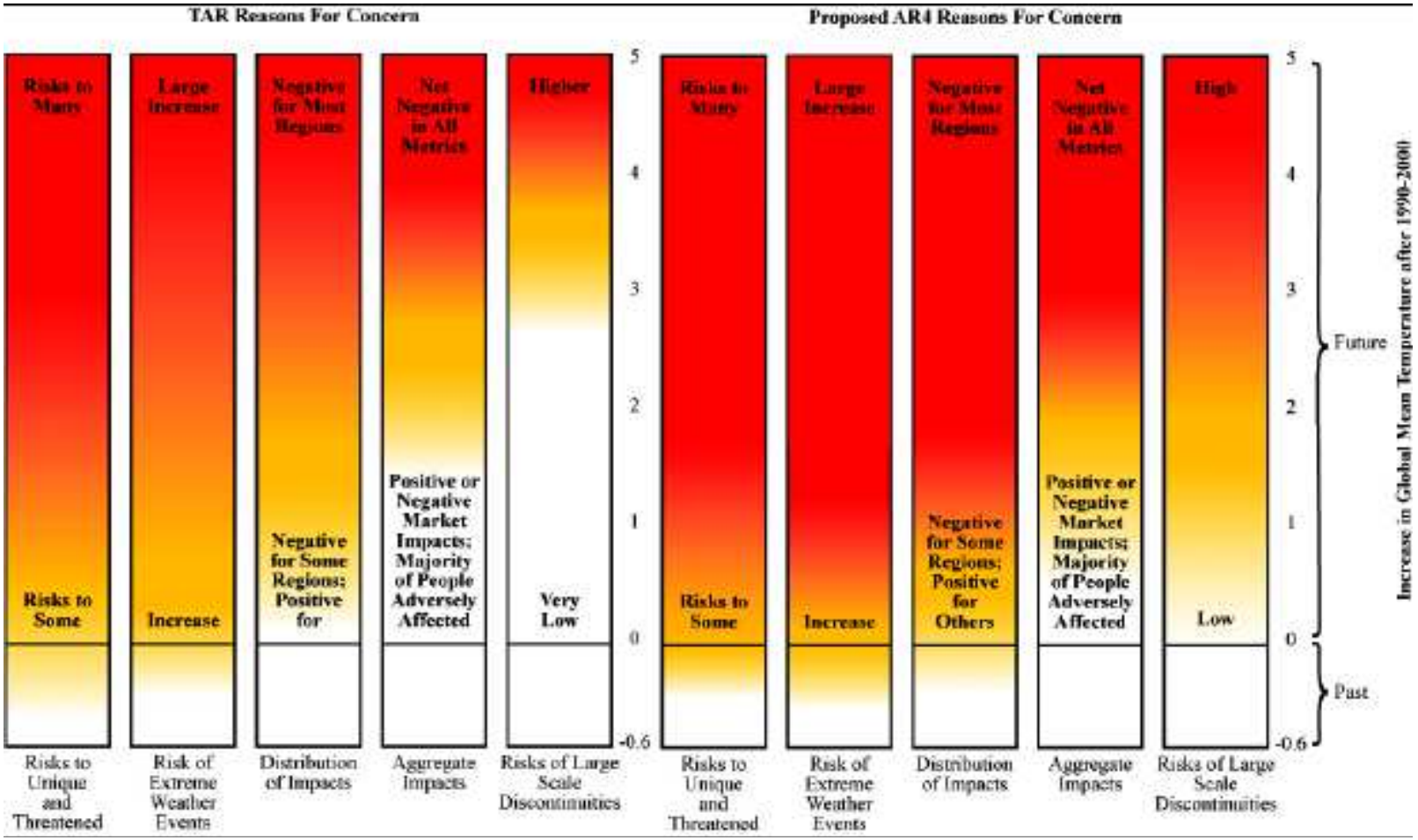
Issues in Designing Adaptive Responses

- What to monitor?
  - Type I errors
  - Type II errors
  - Type III errors
- What to do when triggers are crossed?
  - Transparency of monitoring
  - Transparency of adjustments
- Lead time for responses?
- Panic Intelligently given variability

Portraits of Anticipated Climate Change and Impacts – The TAR (2001)



A Summary Image



Thanks for your atttention