Vulnerability assessments: A transition from the identification of climate change as a threat to incorporation in decision processes

Andrew Blohm [1] and Richard Moss [2]

[1] Earth System Science Interdisciplinary Center, University of Maryland

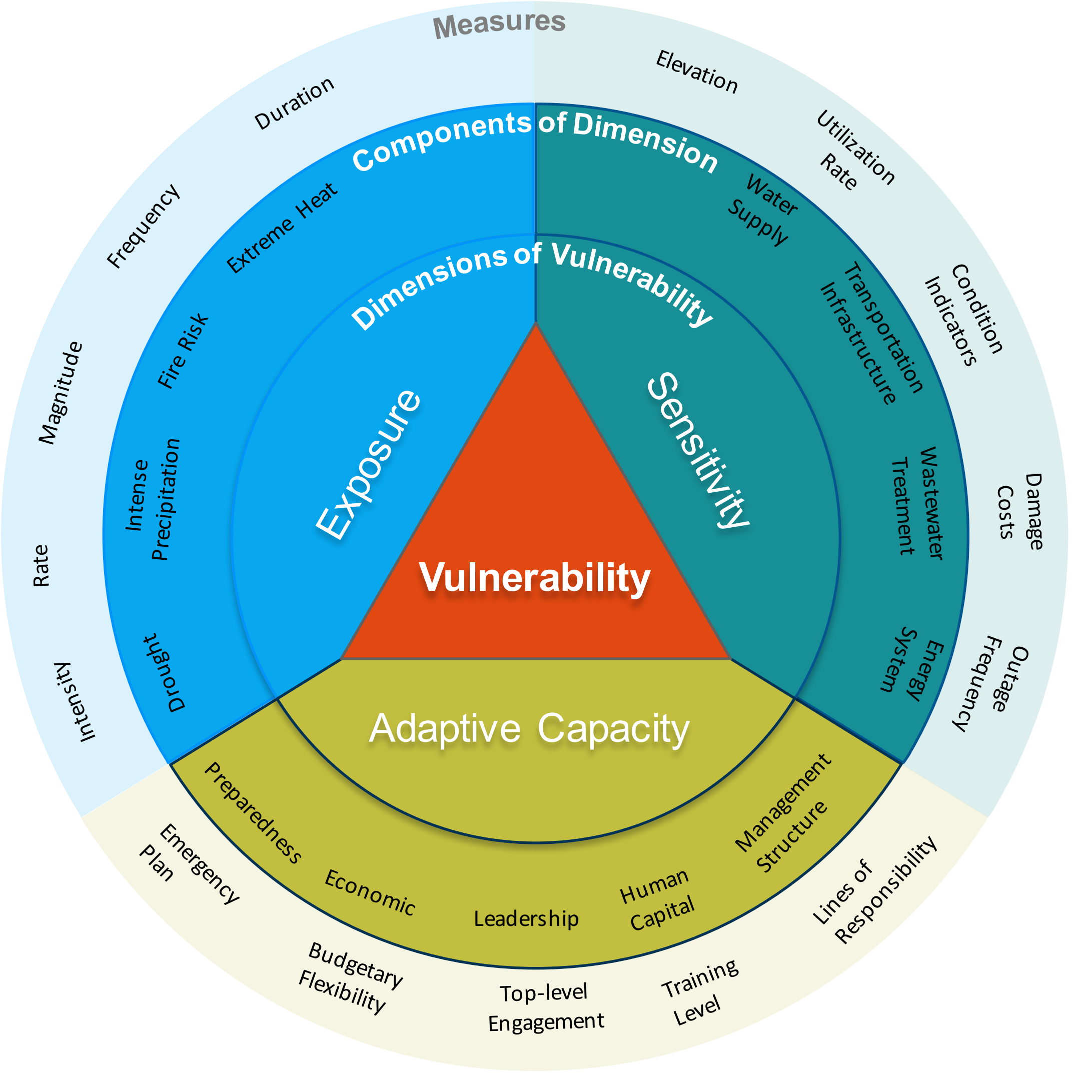
[2] Pacific Northwest National Laboratory

Problem statement

- Organizations, governments, etc. are increasingly identifying climate change as a threat to existing infrastructure, personnel, and mission, and as a result they recognize the need to identify the vulnerabilities of their systems. However, neither a set of best practices nor off the shelf toolboxes exist for the implementation of a vulnerability assessment.

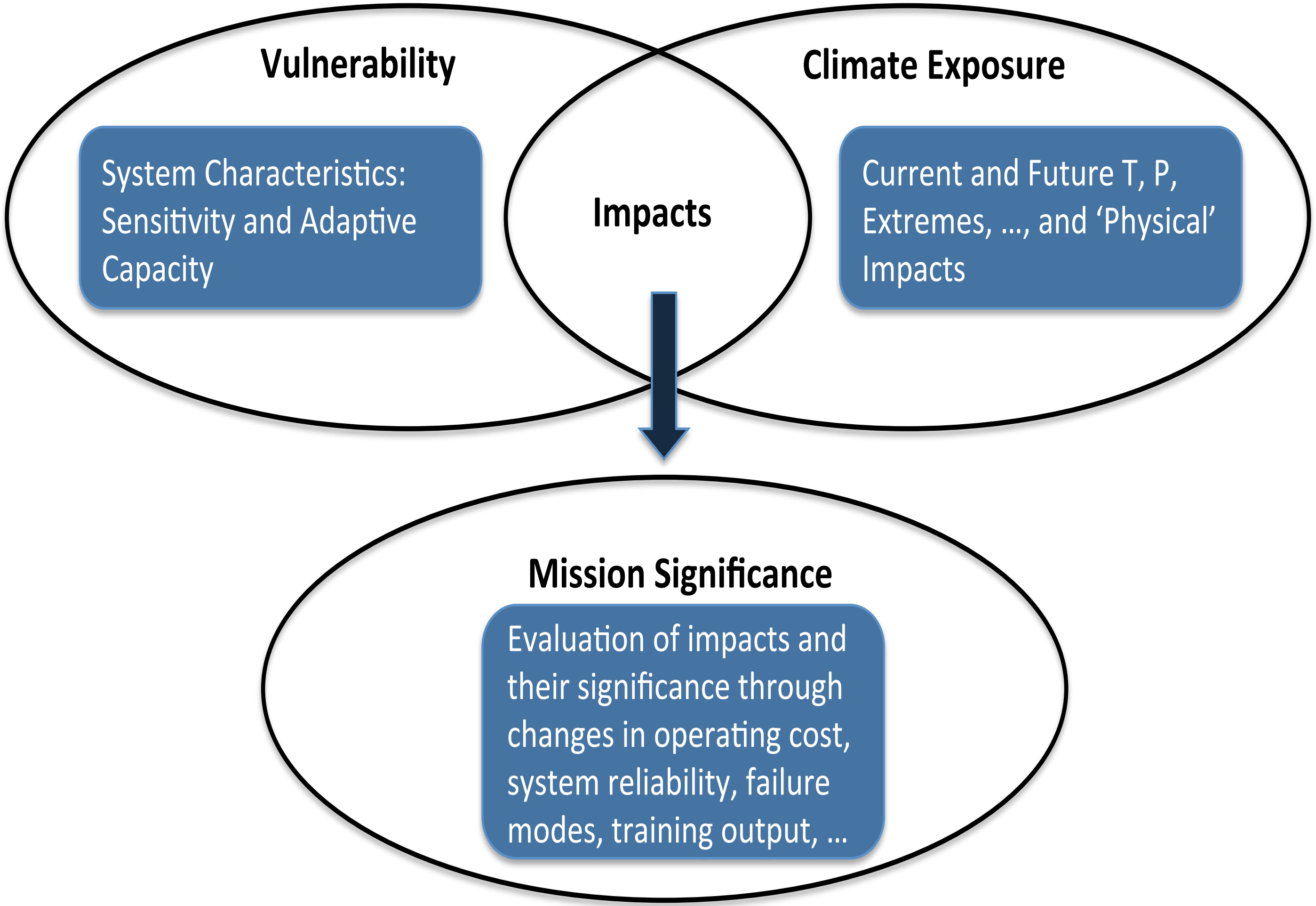
An evolving vulnerability assessment framework

- Our initial definition of vulnerability, as arising from exposure, sensitivity, and adaptive capacity was potentially confusing.
- It conveyed to participants that a vulnerability assessment could not begin until detailed information about exposure to future climate conditions was provided (example: severe storms and current level of modeling)
- We found this to be counterproductive, as assessing local conditions is crucial for identifying and understanding the potential significance of climate change for mission attainment.
- Further, it can proceed in parallel or even before development of information on future climate (example: reducing the dimensionality of climate output data)



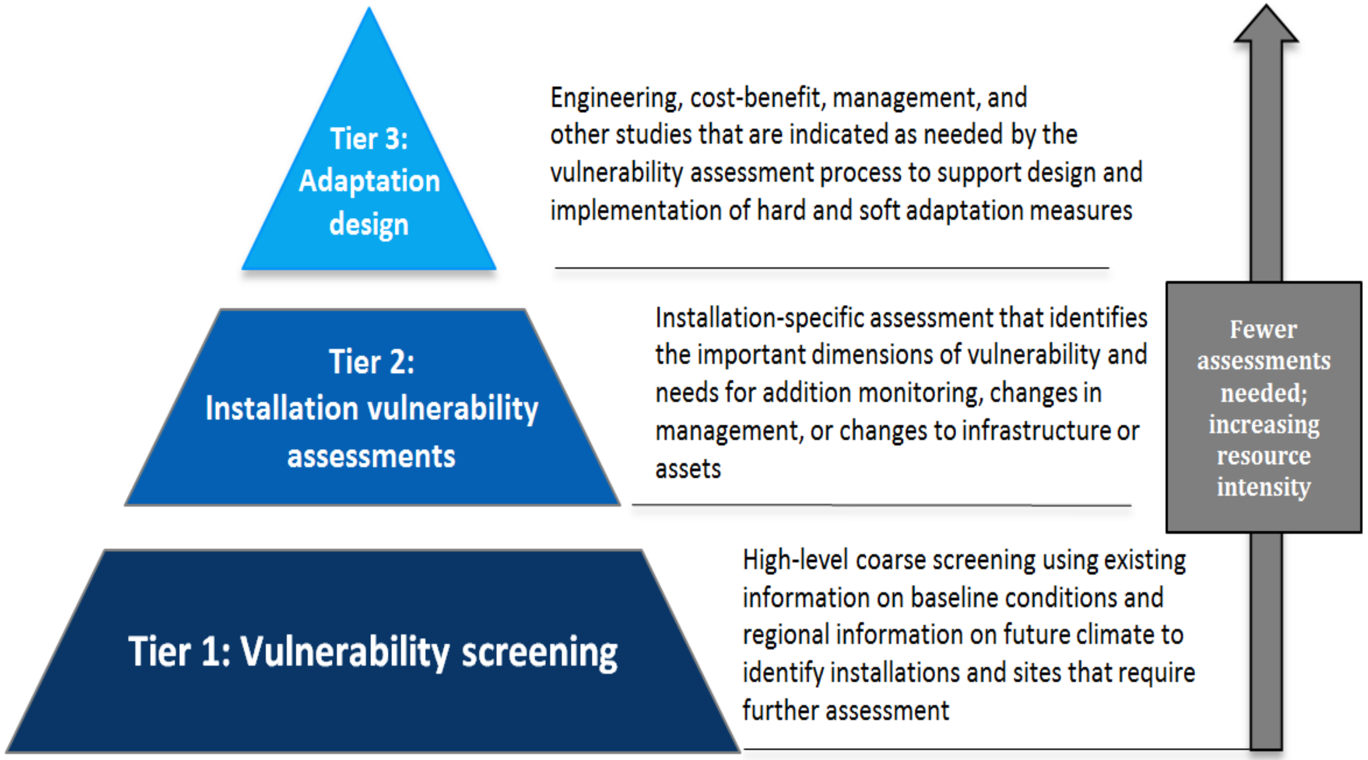
An evolving vulnerability assessment framework

- We suggest revising the conceptual approach used in future facility vulnerability assessments to define *vulnerability* as a function of the characteristics that affect the susceptibility of the site to damage, thus emphasizing sensitivity and adaptive capacity.
- *Exposure* is still crucial but now distinct from vulnerability and depends on the evolution of the climate system and related environmental conditions.
- This formulation more clearly distinguishes the baseline characteristics of facilities from the exposures that act upon those vulnerabilities to produce impacts—the resulting damages, injury, or harm (for example, the physical damage to a building, bridge, or training area).



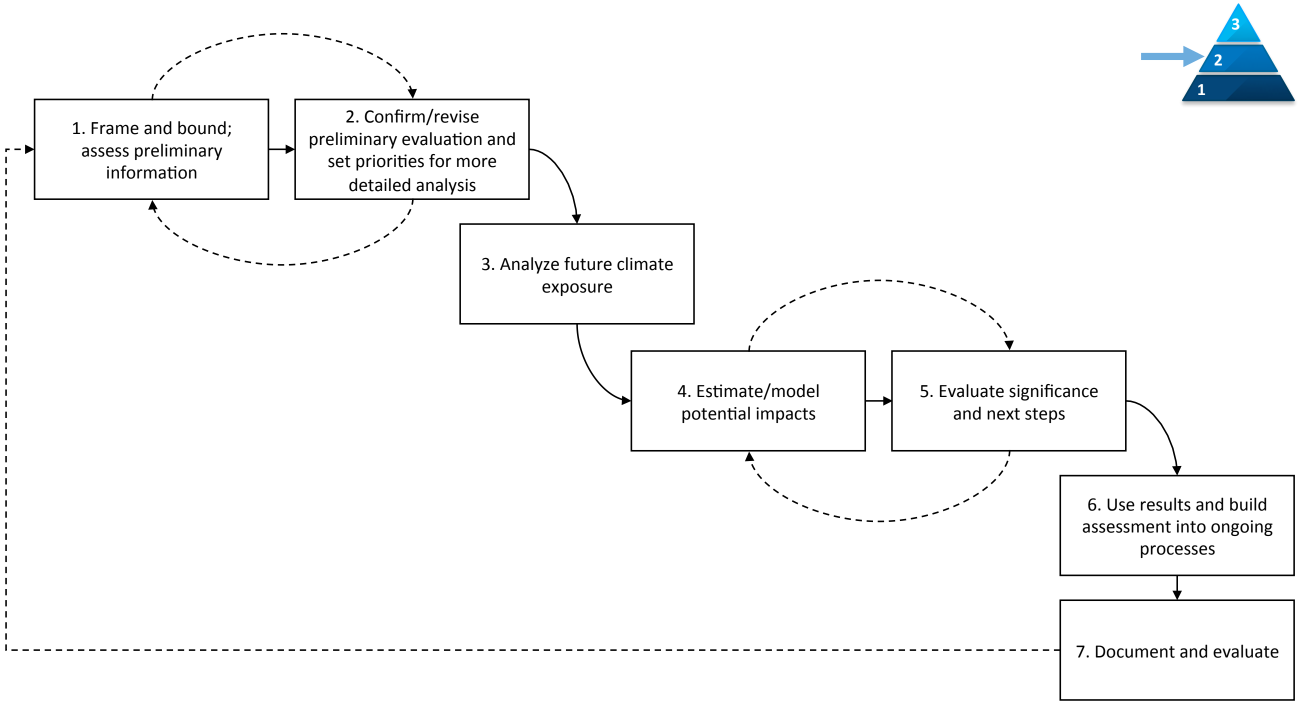
Vulnerability assessments: three tiers

- It is not necessarily optimal to allocate resources for vulnerability assessments evenly across all sites (some sites are more vulnerable than others).
- The Tier 1: Vulnerability screening includes a screening of all agency facilities to set priorities. In a situation in which financial and other resources are not sufficient to conduct tier 2 assessments at all sites, department- or program-wide comparative analysis of sites can establish priorities for additional vulnerability assessment.
- The Tier 2: Installation vulnerability assessment focuses on more detailed assessments at facilities identified as most vulnerable to identify needs for additional monitoring, alterations in management practices, or structural changes.
- The Tier 3: Adaptation design comprises analysis of adaptation options using other frameworks currently employed in capital planning, design, and management.
- The main distinctions across these tiers are the objectives supported and the corresponding level of detail and quality of data required. Tier 1 and 2 each require information about baseline conditions and potential future exposure—simply completing an assessment of current conditions and impacts from ongoing climate variability will not be sufficient to identify whether assets are at risk and the next tier is needed.



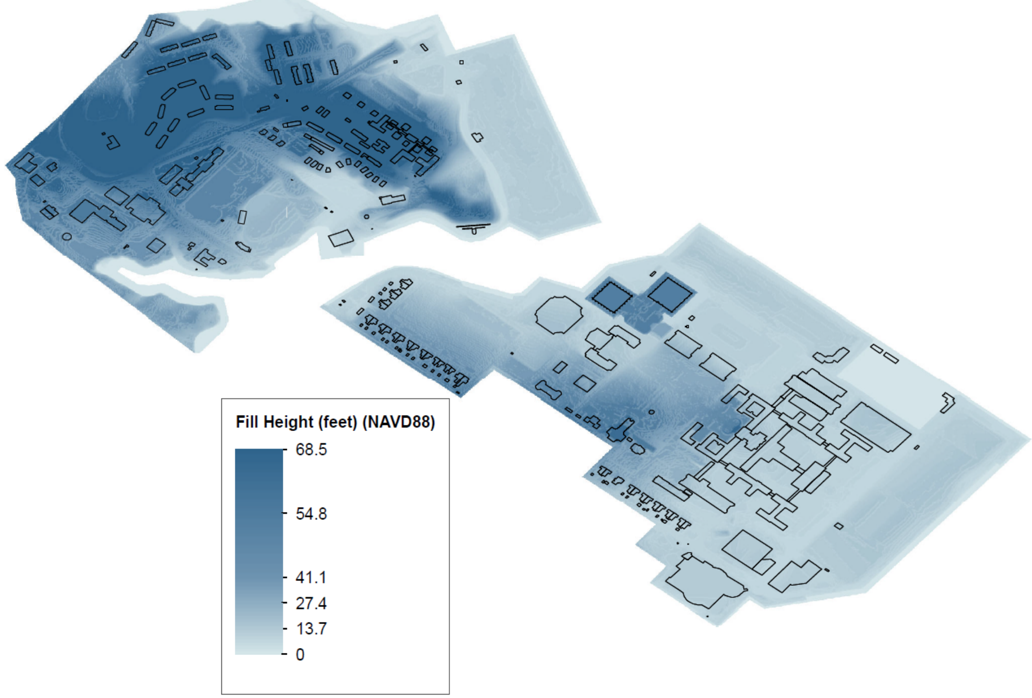
Vulnerability assessment: proposed framework

1. Frame the assessment: Establish purpose, set system boundaries, and collect/analyze preliminary information
2. Confirm/revise preliminary evaluation and set priorities for more detailed analysis
3. Analyze future climate exposure
4. Estimate/model potential impacts
5. Evaluate significance and next steps
6. Use results and build assessment into ongoing processes
7. Document and evaluate assessment process



Case study: Annapolis, MD

- <u>Framing and bounding the assessment:</u>
- The USNA is the cultural and educational center of the Navy (Naval officers produced here)
- The campus is located in Annapolis, Maryland at the mouth of the Severn River as it enters the Chesapeake Bay and is vulnerable to flooding and sea level rise.
- Through discussions with installation managers we identified flooding and sea level rise as threats to the mission of the installation (i.e., training and education).
- Other issues such as extreme heat impacts on training were less of a concern given adaptation options (going indoors, moving training times, etc.).

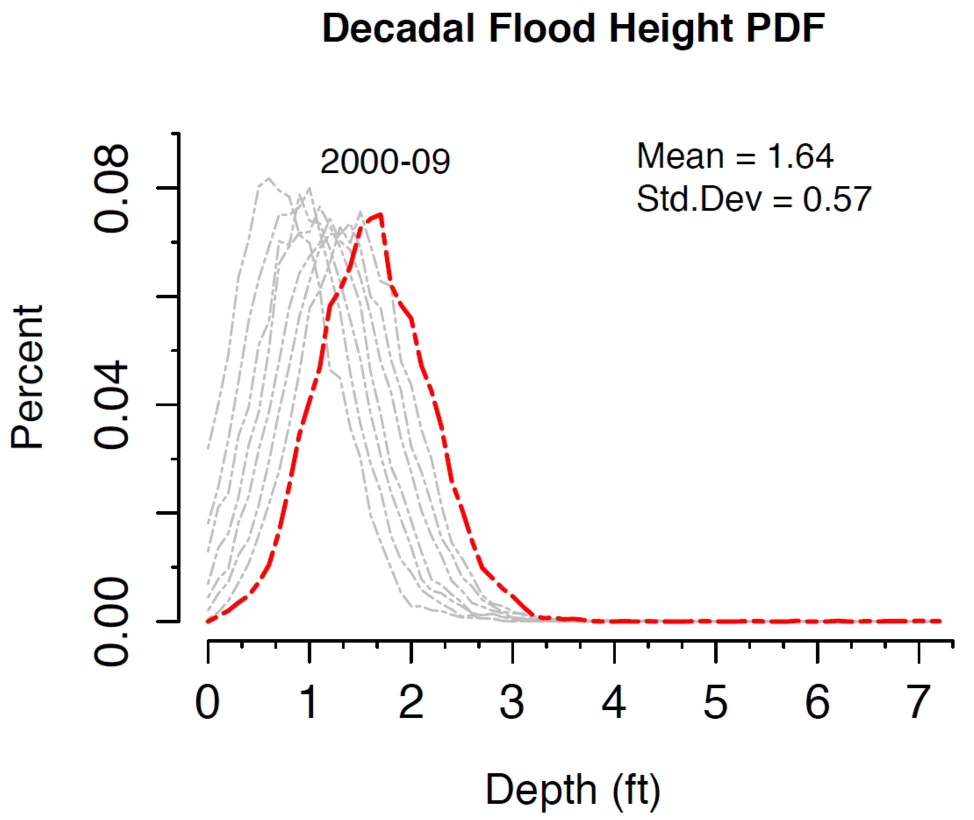


Case study: Annapolis, MD

- Hurricane Isabel caused an estimated $150 million USD in damage to the USNA.
- Much of the damage occurred in one building (mechanical equipment in a basement) though it also highlighted bad management and maintenance practices (drilling holes in buried conduit pipes carrying sensitive wiring and equipment).
- Led to a number of proposed and adopted adaptation measures (e.g., storm monitoring, dialogue with NOAA, sea wall construction, increasing road heights, elevating transformers, etc.).
- Institution knows that flooding is a vulnerability but as of right now existing management alternatives appear to be enough

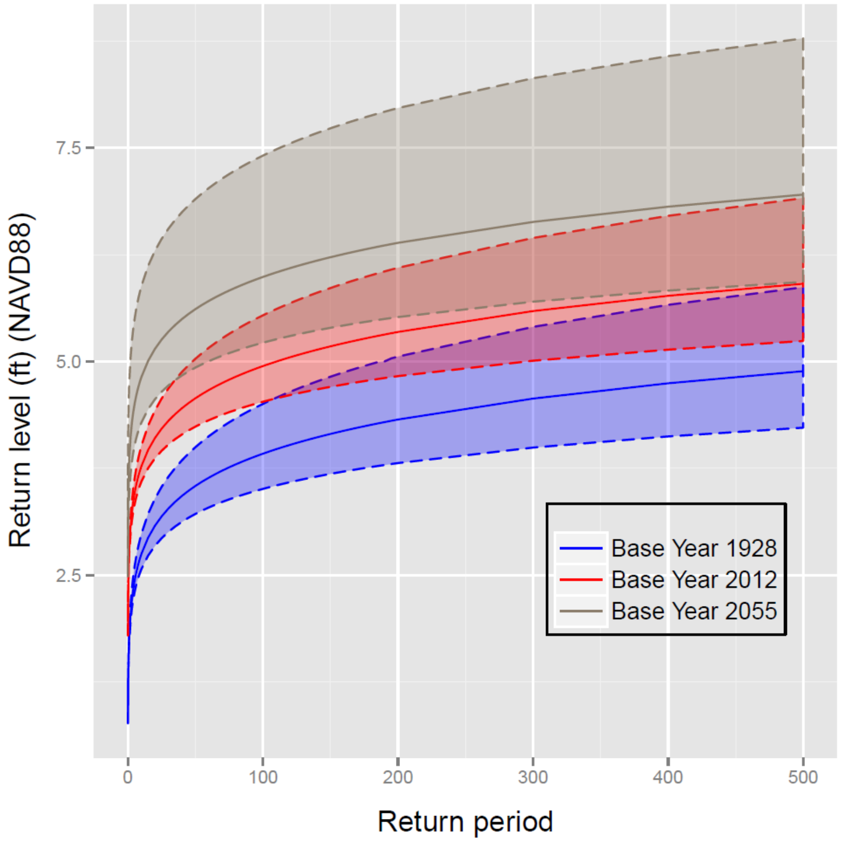
Case study: Annapolis, MD

- <u>Baseline exposure:</u>
- The water levels as measured at the USNA tide gauge are rising (located in the USNA harbor).
- The figure at right reflects the change in water level likelihood over the period 1928 to present.
- From the digital elevation model (Slide 7) and the figure to the right, we can see that on most occasions existing management practices are sufficient.

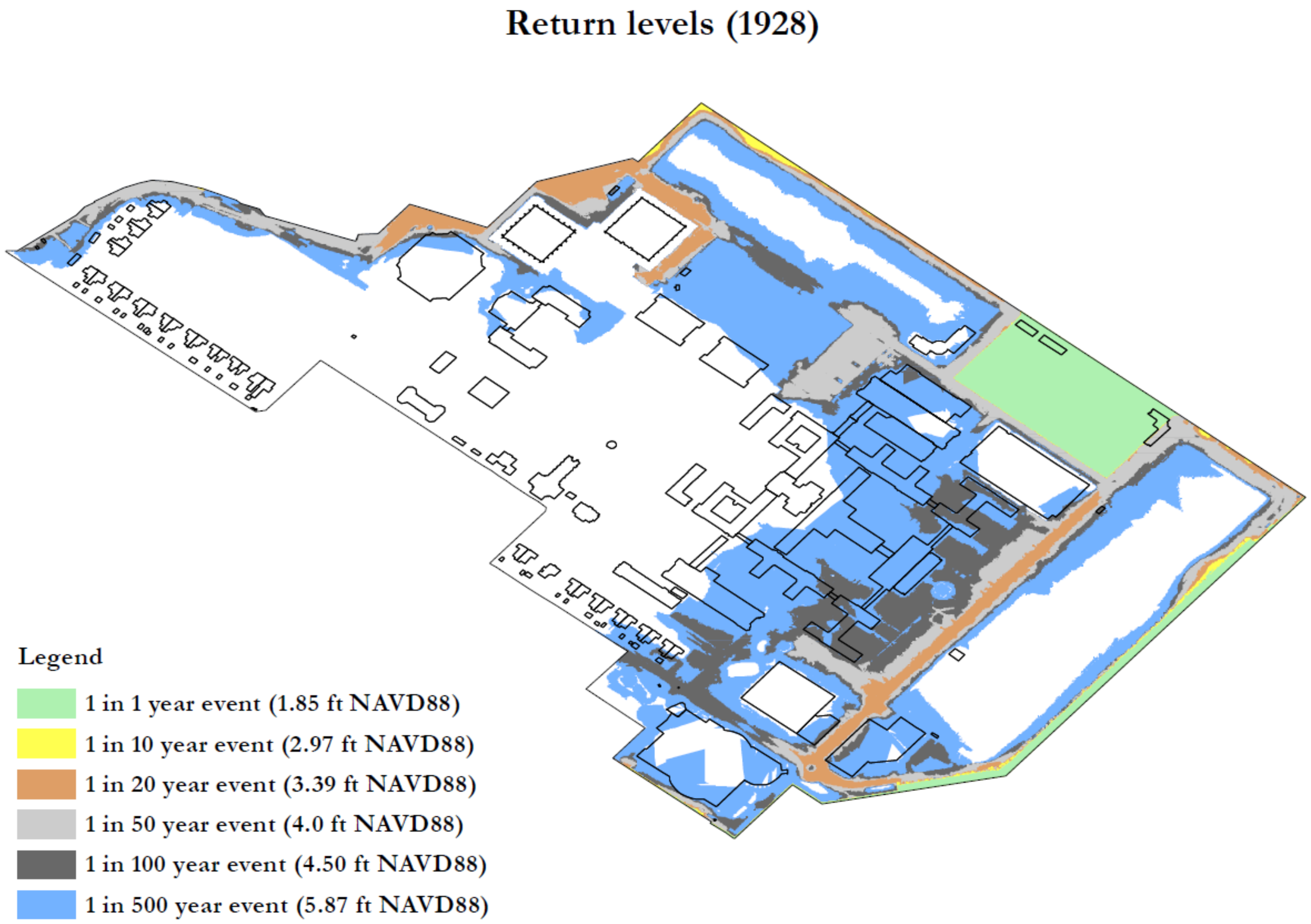


Case study: Annapolis, MD

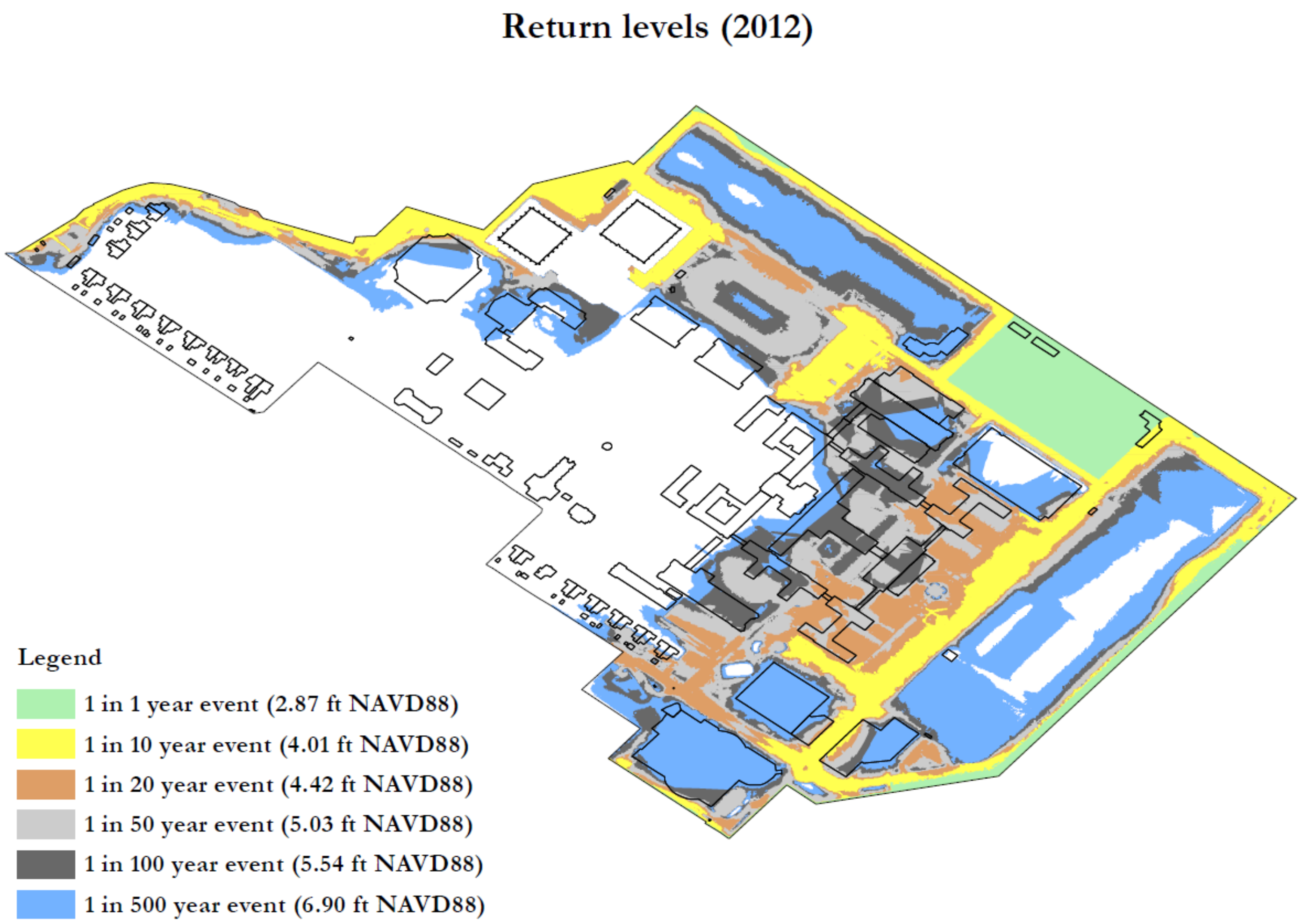
- <u>Baseline and future exposure</u>
- A return period estimates the likelihood of an event (i.e., water level in our case).
- Using the detrended tide gauge record we generate the return periods to the right for 1928 and 2012.
- In addition to the detrended tide gauge record, we also use sea level rise estimates from Tebaldi et al. (2012) to construct the 2055 return period.
- The figure at right shows that the risk profile for the institution is changing. In the next few slides we project these results spatially.



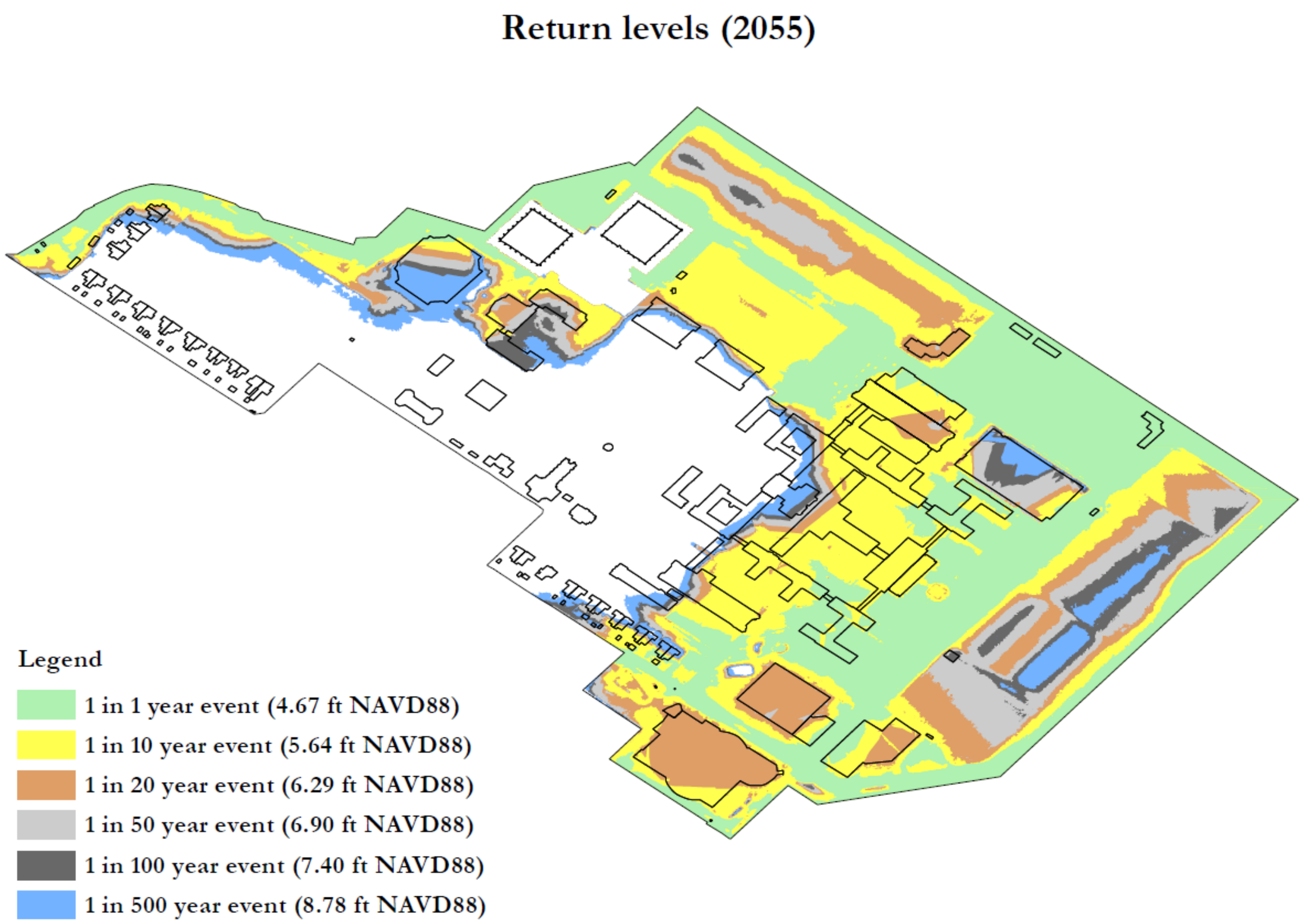
Changing risk profile: Annapolis, MD



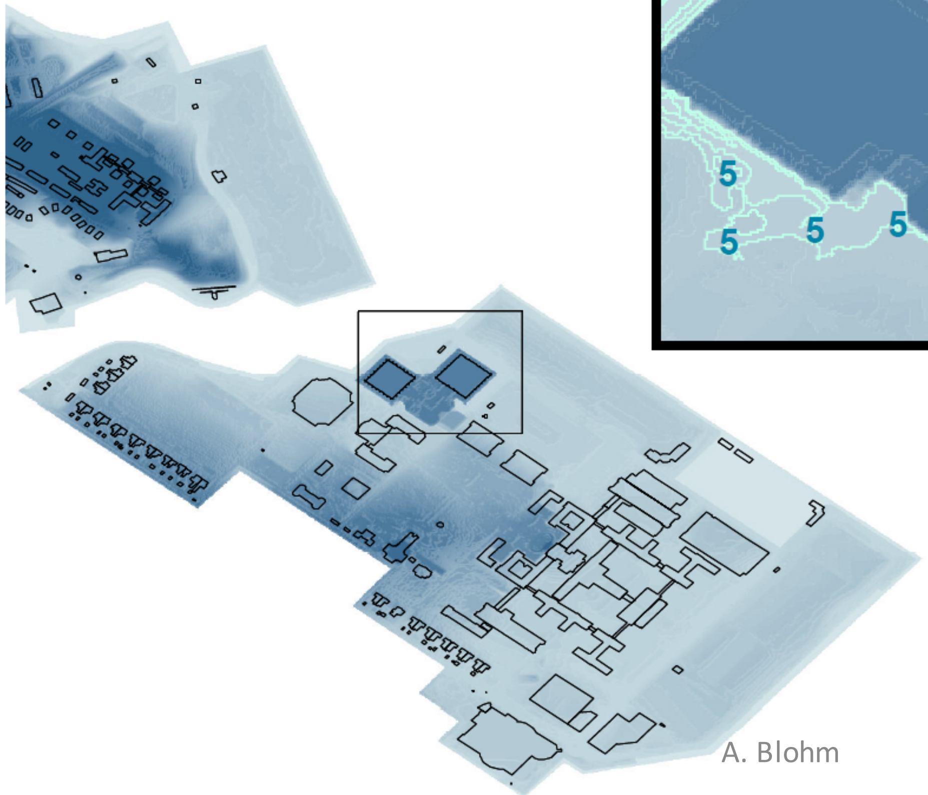
Changing risk profile: Annapolis, MD

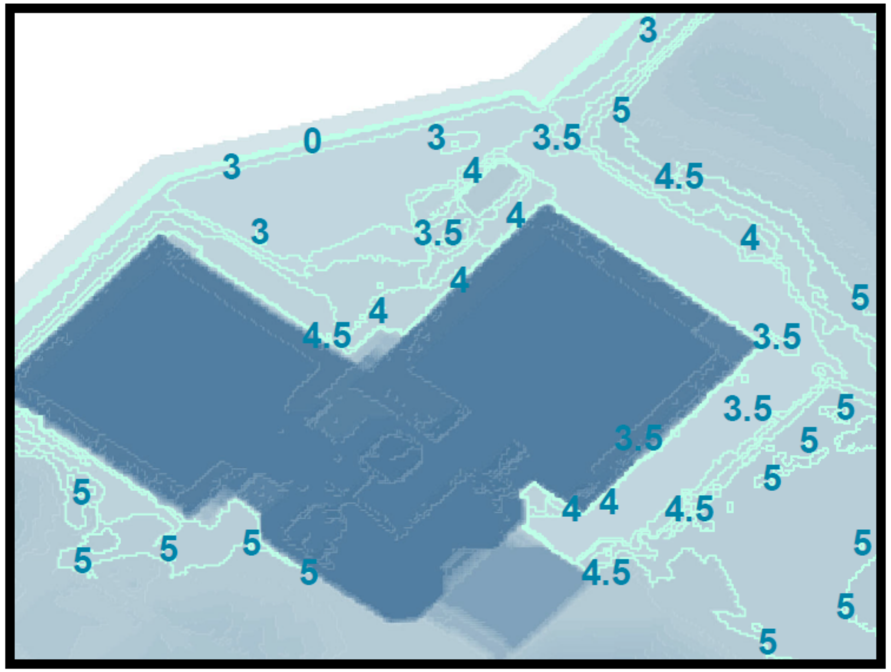


Changing risk profile: Annapolis, MD

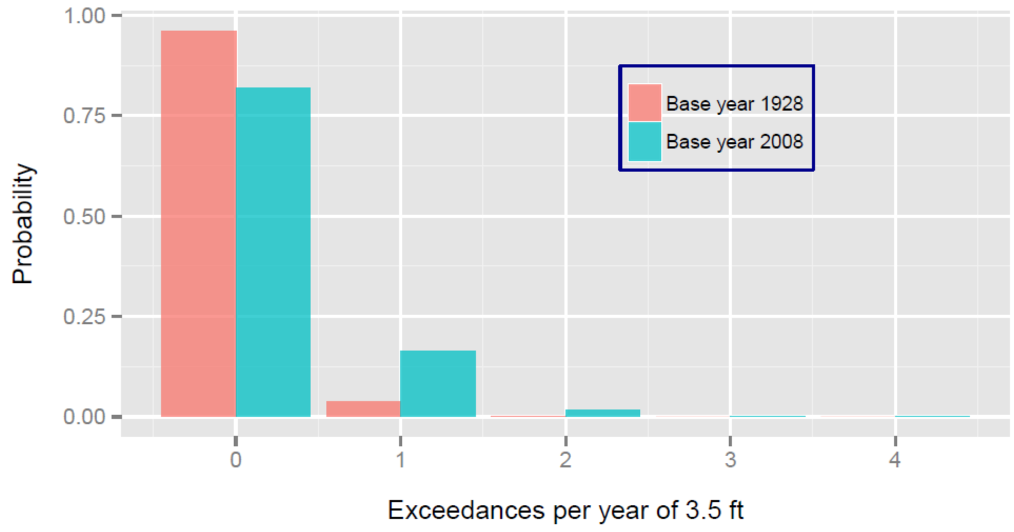


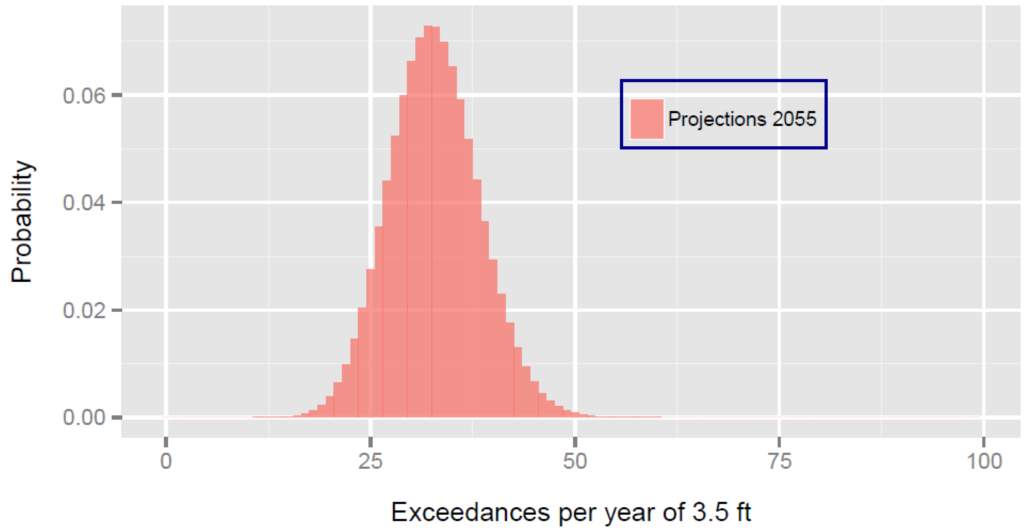
Digital elevation model: USNA





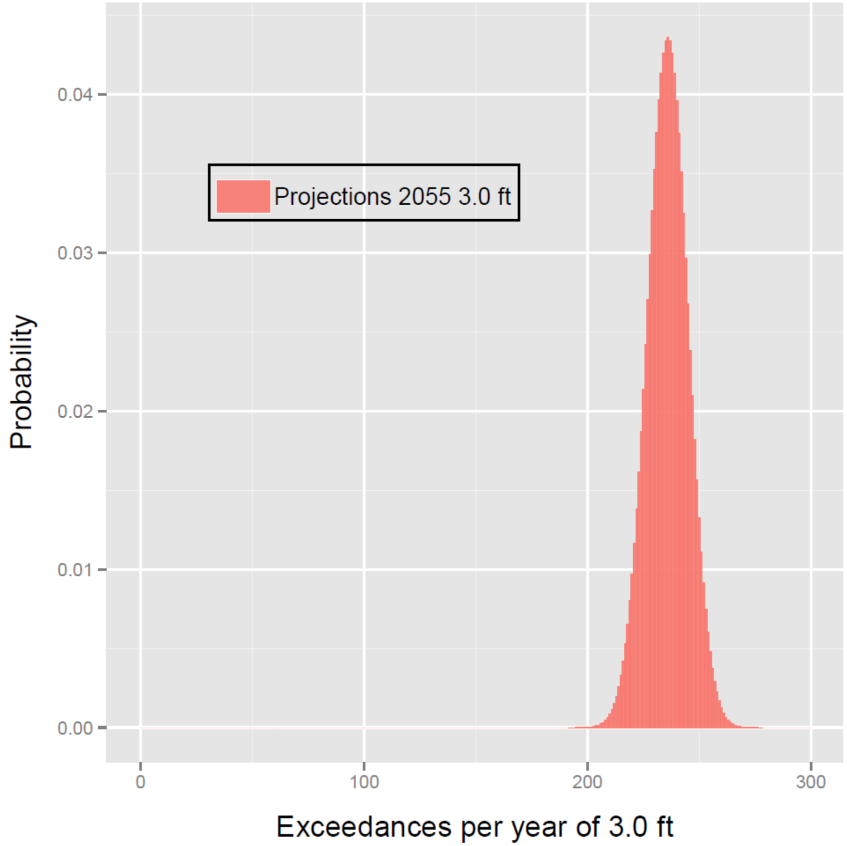
Changing risk profile: Annapolis, MD





Conclusions

- <u>Review:</u>
- There exists a need for vulnerability assessments.
- The selection of the appropriate stakeholders or audience is an important part of the process with a nonobvious solution.
- We propose that a three-tiered approach to vulnerability assessments. The questions asked at each level are different but there is a flow from one level to another.
- Our experiences suggest that climate outlooks are an efficient vehicle for developing and presenting climate information, though further research is needed.
- Products, such as a return period analysis, are already used by a number of fields including engineering and as a result, are an effective vehicle for communicating changes in the risk profile.
- Communicating information is an often overlooked but important part of the process. We had good experiences using return period maps and mpeg movies (modeled Isable under various SLR scenarios using FVCOM).
- Existing decision making paradigms can prevent investment in risk reduction measures.



Thanks!

- For more information on this or our other work please contact me at andrew.blohm@pnnl.gov or check out our GitHub either through my name Andrew Blohm or my ID andymd26.
- Presentation is available for download at https://github.com/andymd26/presentations

Backup slides

Climate Vulnerability

The project's approach is based on the concept of climate vulnerability.

Climate vulnerability is the degree to which infrastructure, a system, a place, or a population group is susceptible to and unable to cope with adverse effects of climate variability and extremes and/or changes in future climate.

Vulnerability encompasses exposure to climate change, its sensitivity, and its adaptive capacity. The diagram at right illustrates how vulnerability can be quantified by focusing on specific components and measures of exposure, sensitivity, and adaptive capacity. Not all of the dimensions may be necessarily relevant for any single installation. Those discussed in this report are based on a subset of climate factors chosen for analysis because of the current sensitivities at JBLE.