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Agenda

- Introduction and Overview
- Vulnerability Assessment and Flood Mitigation Analysis
- Selecting Mitigation Options
- Project Findings and Deliverables

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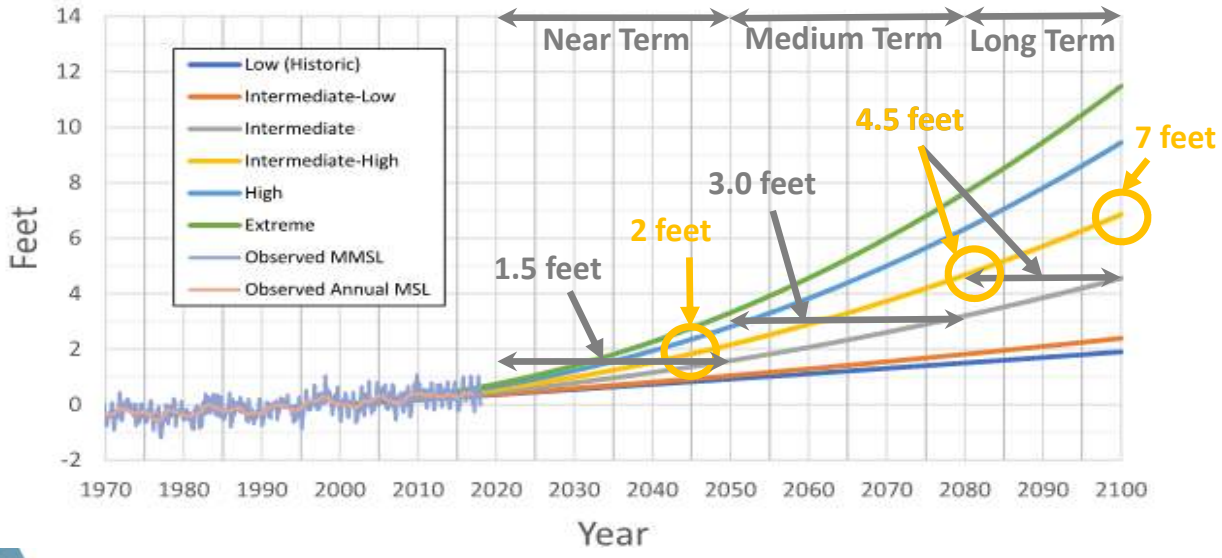
Climate Change Planning is Long Range

- HRSD's Climate Change Plan will address the next 80 years of climate change impacts.
- This 1st version of the plan will be developed to provide a foundation for future updates and utilize varying levels of detail based on the timeframe and magnitude of facility vulnerability.

Planning Horizons and SLR Scenarios

for Flood Risk and Mitigation Measure Benefit Determination



Reference HRPDC, 2018. Figure 2: Updated NOAA Sea Level Rise Scenarios for Norfolk, VA

HRSD Facilities

For Flood Risk Evaluation

- 8 Large TPs
- 5 of 8 Small TPs
- 19 PRSs
- 104 of 115 PSs
- 3 Admin/Ops Sites

139 of 153 Existing Sites

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Flooding Sources

Flooding Sources	Description	Defining Characteristics
Coastal 	Storm Surge Flooding	Storm induced water levels resulting from atmospheric pressure changes and wind
Fluvial 	Riverine Flooding	Watershed hydrology and conveyance capacity of channel and floodplain geometry
Pluvial 	Rainfall Flooding	Local hydrology and conveyance capacity local drainage features, such as topography, pipes, ditches and culverts

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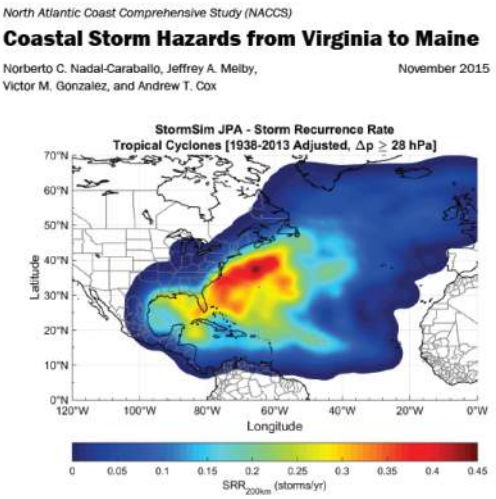
Flooding Source Evaluation Methodology

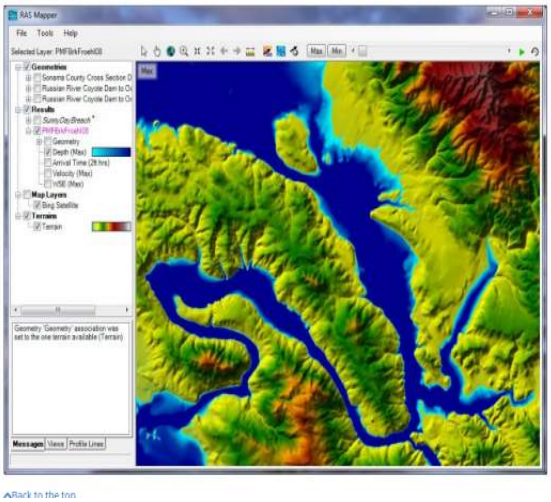
- Coastal:
  - North Atlantic Comprehensive Coast Study (NACCS) Model developed by USACE
  - Includes sea level rise
  - Dominant flooding source for majority of HRSD facilities
- Fluvial
  - Simplified riverine hydraulics
  - Initial basis: FEMA Flood Insurance Study
  - Dominant flooding source for approximately 10 HRSD facilities



Pluvial Flooding Evaluation Methodology

- Leverage approach used by FEMA to enhance flood maps nationwide
- Topography – Available LiDAR data
- Hydrology
  - Design storms developed for the planning horizons
  - Routing computed using an assumed curve number based on landuse
- Hydraulics
  - Overland conveyance computed with mesh defined based on the terrain (LiDAR) data

HEC-RAS Software



Arctic Avenue Pump Station Example

- Found to be at risk to flooding (storm surge) for existing conditions, which worsens overtime.
- Interim flood mitigation (combination of stop logs, floodwalls, and flood gates) reduces the flood risk and results in a positive benefit-cost ratio.
- At the end of its useful life during a redesign (2068) the station may be raised for further flood protection

Arctic Avenue PS

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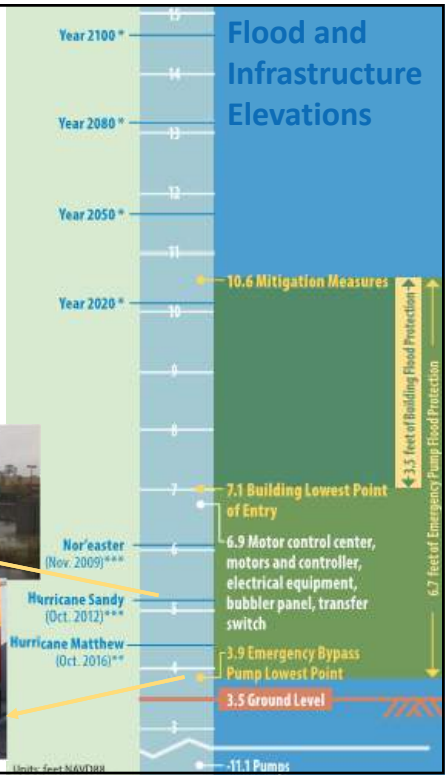
Data Collection to Establish Site-Specific Details

- Identify core functions and core functions assets based on HRSD criticality assignments
- Obtain bottom elevation of core function assets*
- Identify Lowest Point of Entry (LPE) of flood water*
- Obtain flooding history from Operations, NOAA and USGS



* One percent chance annual recurrence interval flood elevation estimated using the Intermediate Climate Change Scenario.

** At the USGS Tide Gauge 0204295505, Broad Bay- Little Neck Creek branch 1/3 miles from the HRSD site.

*** At the NOAA Sewells Point Tide Gauge.

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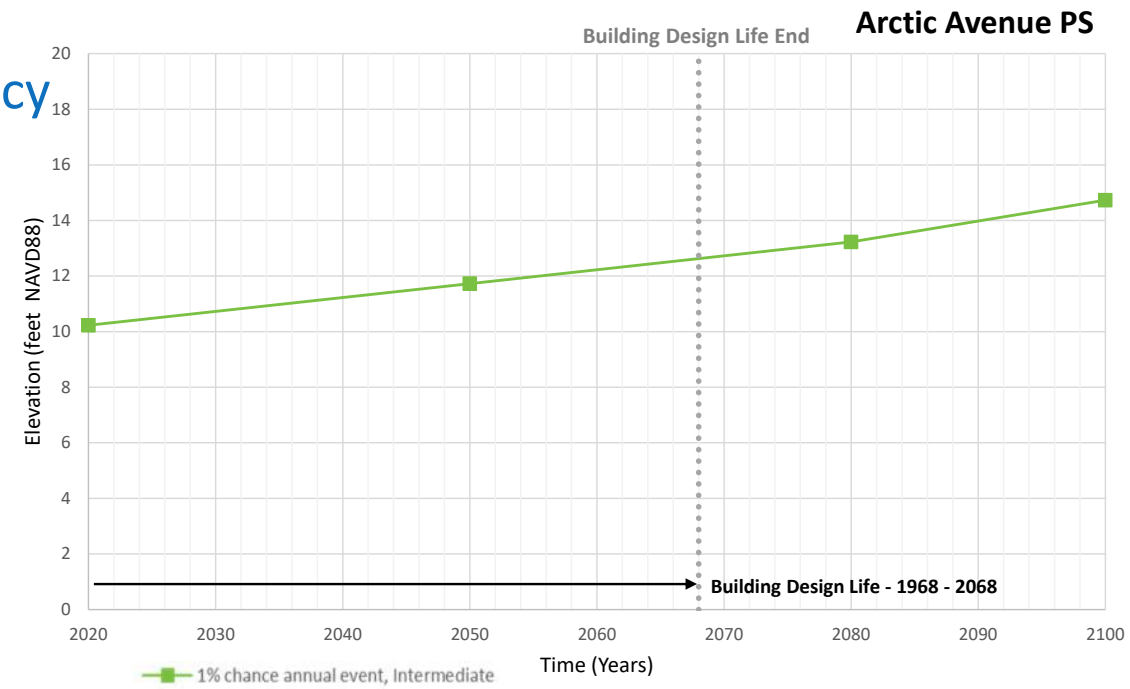
Flood Frequency Graph

Intermediate Scenario



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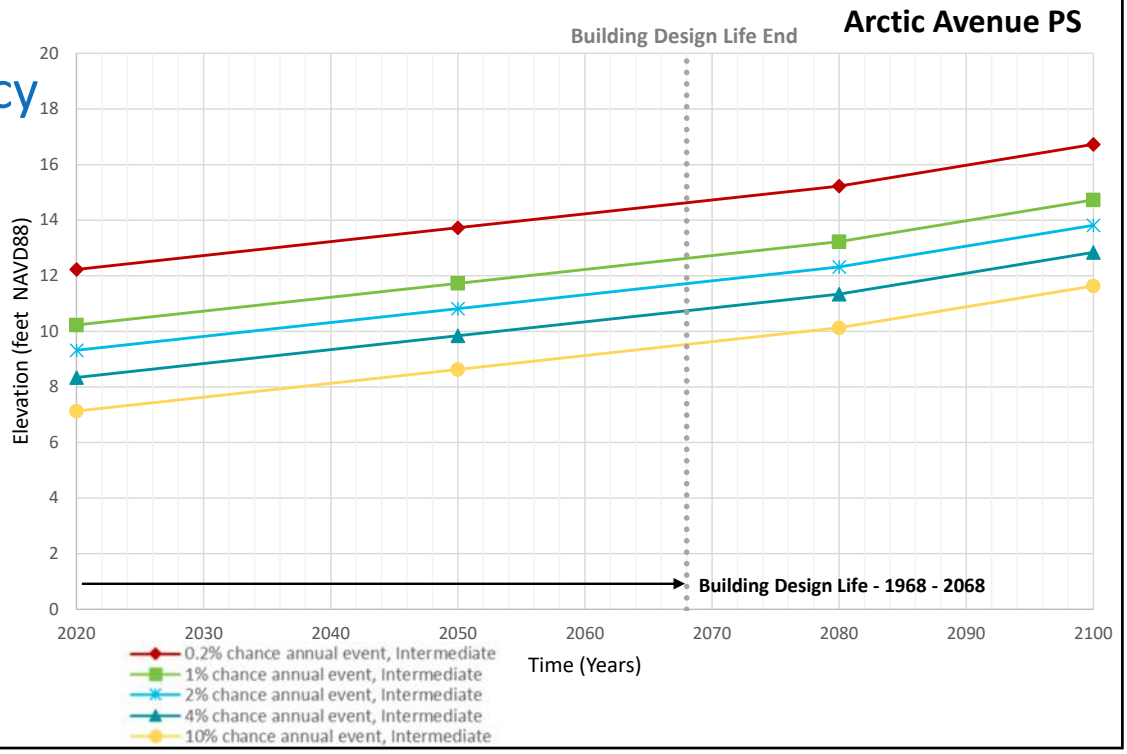
Flood Frequency Graph

Intermediate Scenario



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Determine Site-Specific Flood Mitigation Measures

Considerations:

- Understand site features (e.g. outside generator or bypass pump)
- Review site layout and physical constraints
- Consider site aesthetics and community acceptability
- Avoid triggering Substantial Improvement requirements

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Flood Frequency Graph with Site Details

Intermediate Scenario

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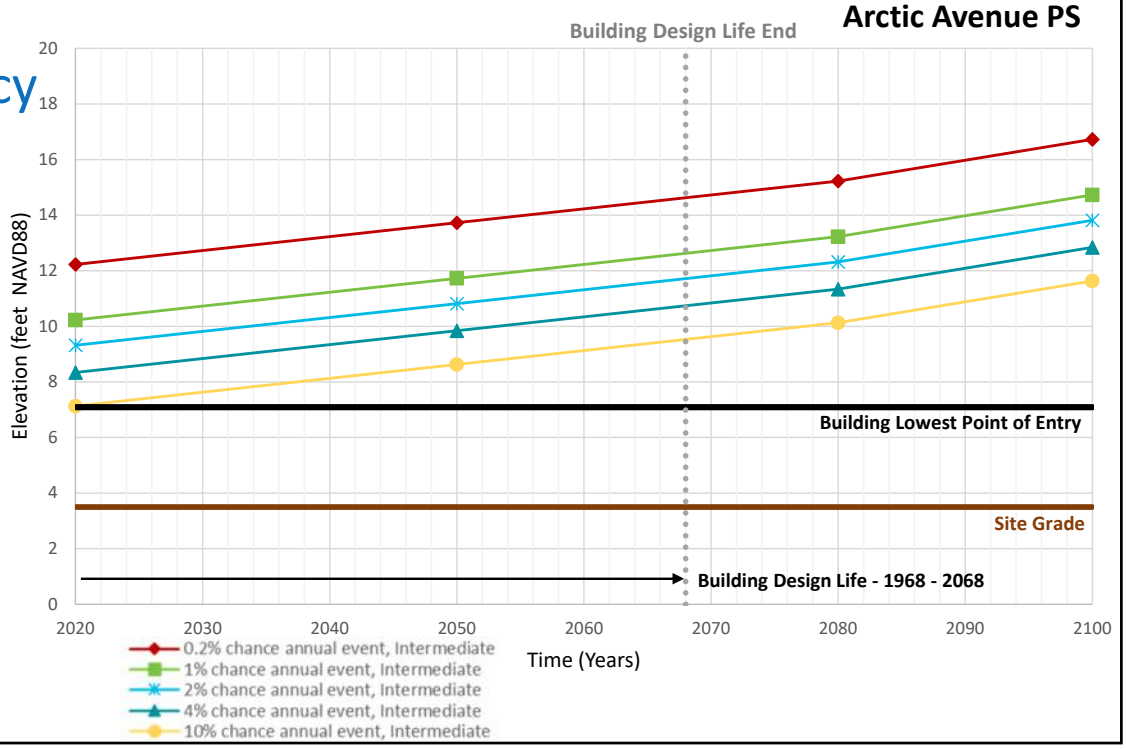

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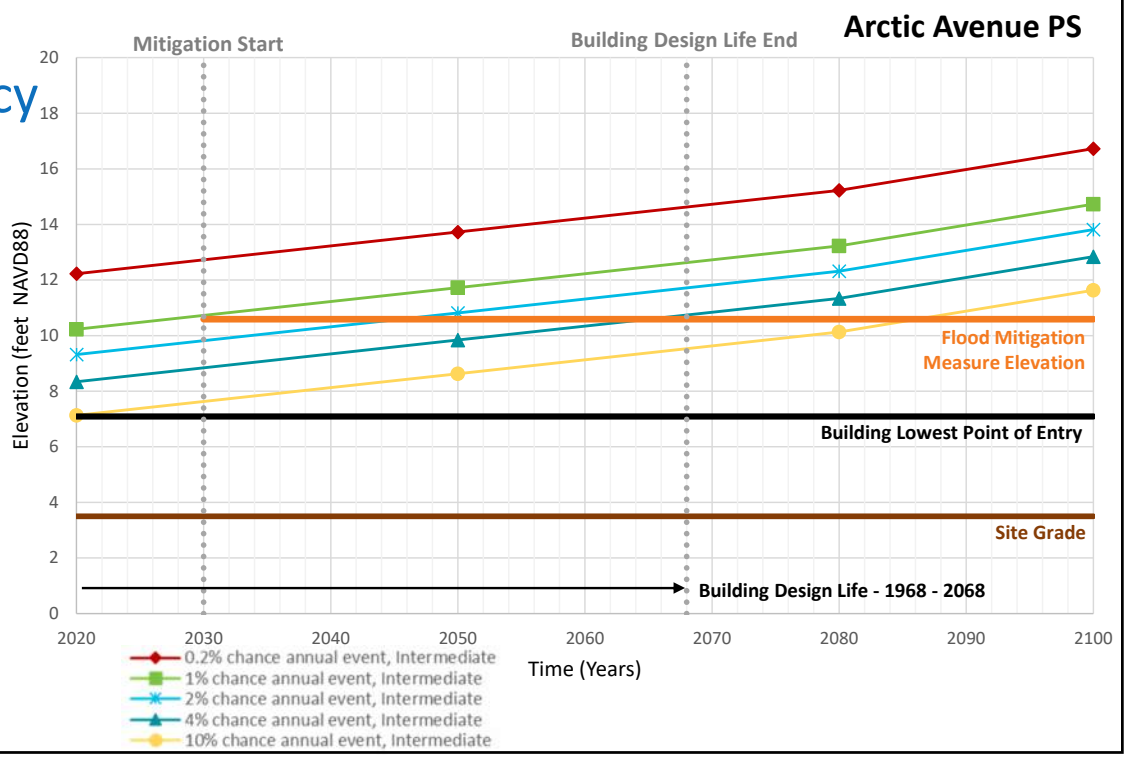
Flood Frequency Graph with Site Details

Intermediate Scenario



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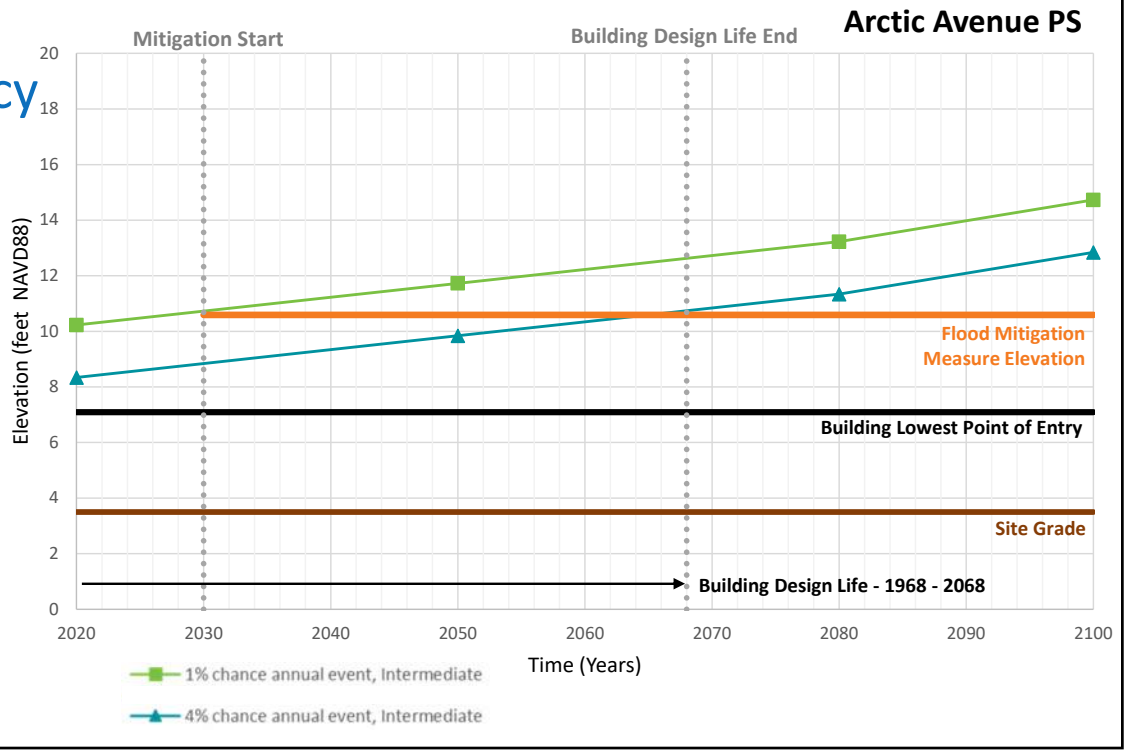
Flood Frequency Graph with Site Details

Intermediate Scenario



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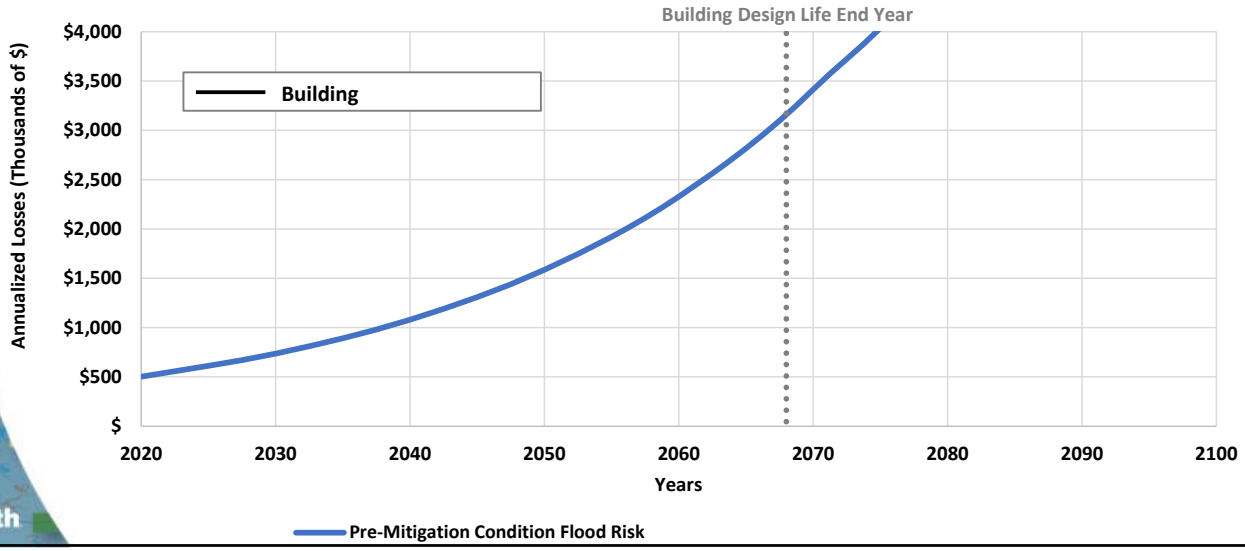
Flood Risk as Annualized Losses Over Time

Intermediate Climate Change Scenario



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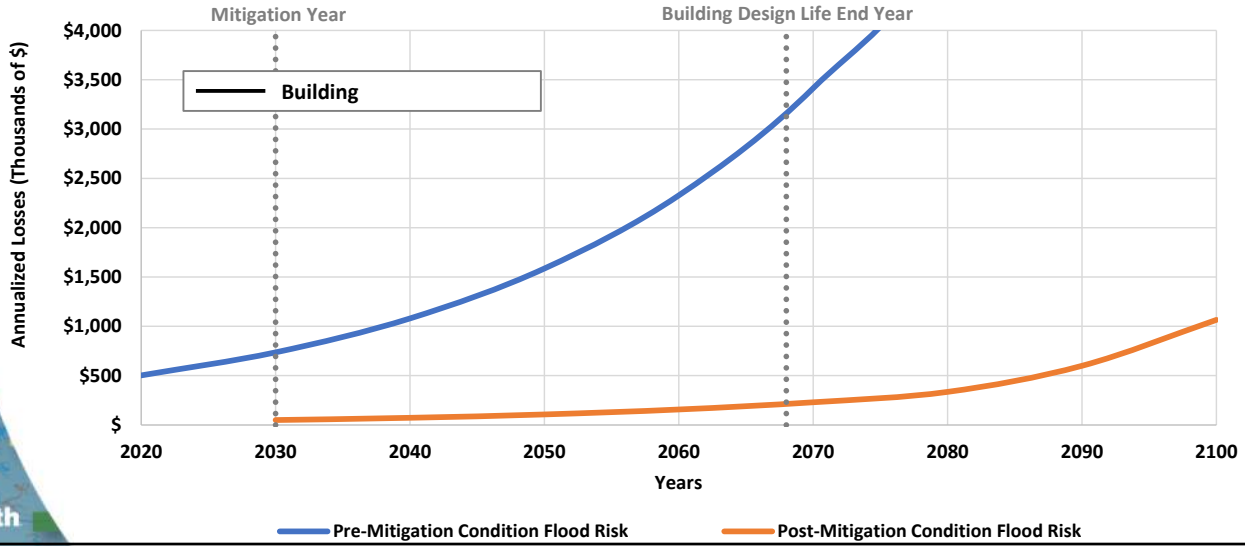
Flood Risk as Annualized Losses Over Time

Intermediate Climate Change Scenario



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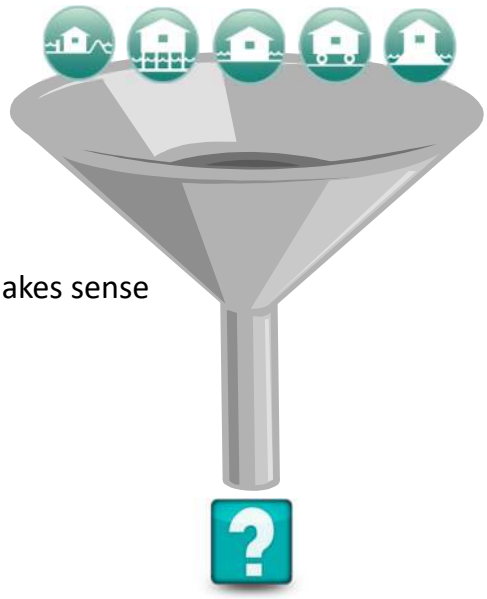
Selecting Mitigation Options

- **Technical Considerations**
  - Building characteristics
  - Flooding/SLR characteristics
    - Not focusing specifically on 100-year flood
    - Pick a design level of flood protection that makes sense
  - Site characteristics
    - Can passive measures be introduced
- **Operational Considerations (incl. Safety)**
- **Economic Considerations**



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Dry Floodproofing Concepts

- Keep the water out
- Walls must be “substantially impermeable” to passage of water
- Requires human intervention
- Allow time for intervention
- Methods include shields and barriers, waterproofing or sealants, backflow preventers, drain stops

Dry Floodproofing must be done <u>100% correctly</u> to be effective; there is no “partial credit”.
Dry floodproofing often fails due to a minor oversights

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Dry Floodproofing Considerations

Attribute	Issues for Consideration
Building strength	• Can the building resist flood-related forces? • Can retrofits be made to strengthen the structure?
Warning time	Is warning time required to activate or deploy a floodproofing measure?
Flood characteristics	Is flooding at the site expected to last longer than 12 hours?
Level of protection	Are floodwaters at the site expected to be greater than 3 feet?
Building location	Is the building in a Coastal A Zone or Zone V?
Operational considerations	Can considerations for the dry floodproofing measure be added to existing maintenance plans?

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Dry Floodproofing Considerations (Cont.)

Attribute	Issues for Consideration
Seepage considerations	• Are there measures to remove any water that infiltrates the building necessary? • Have all potential sources of leaks been sealed?
Utilities	• Can underground utilities be sealed to prevent backflow of floodwater into the building? • Can electrical utilities below the flood protection level be protected from floodwaters?

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Climate Change Plan – Deliverables

Data

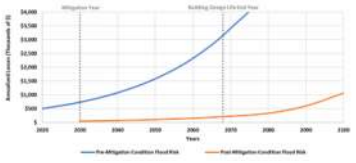
- Flood elevations database
- Vulnerability cost and losses database
- Mitigation costs, benefits

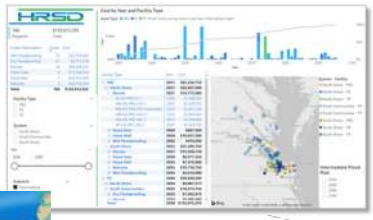
Decision Support

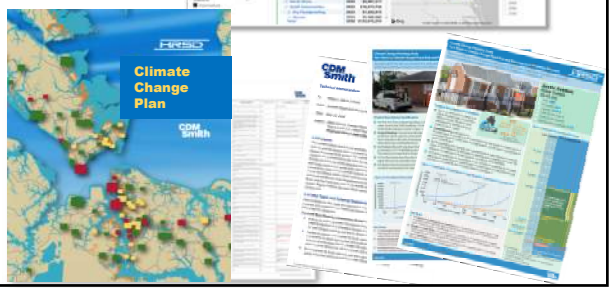
- Visualization dashboard
- Aggregated view of vulnerability and mitigation
- Ability to modify the implementation schedule

Documentation

- Highly visual executive summary
- Technical report and appendices
- Product examples to support future implementation

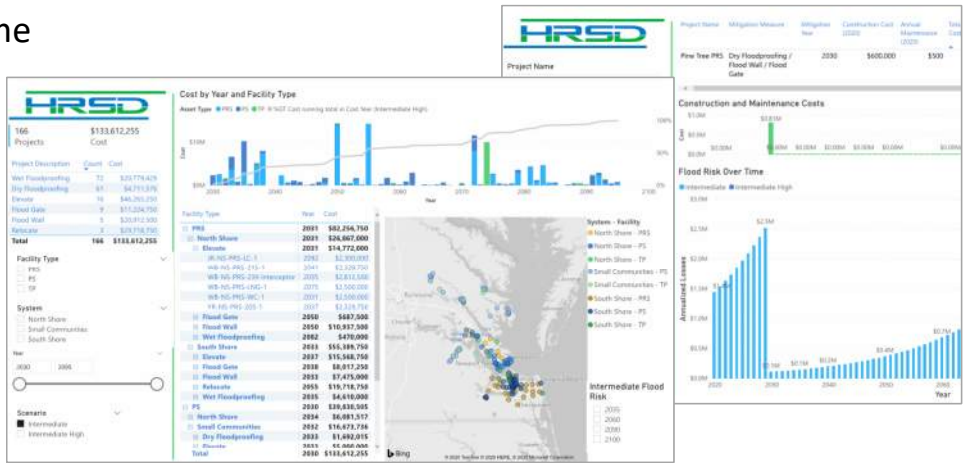






Dynamic Dashboard

- Visualizes, summarizes, and sorts by geography, system, asset-type, or utility-wide: Customizable views for the user's needs
- Flood risk over time
- Conceptual level cost*, schedule, and flood risk for selected flood mitigation measures



**Dashboard allows for cost calculations using future discount rates*

Climate Change Plan Look Ahead

Additional iterations of the plan will be developed over the 80-year long-term planning horizon. This first version of the plan will serve as the starting point for ongoing coordination on local and regional resiliency improvements.

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Questions | Thoughts | Comments | Concerns

Dr.-Ing. **Matthias Wittenberg**, PE, PMP, DWRE, REM
Project Manager
wittenbergm@cdmsmith.com

Michael C. Morgan, PE
Associate Water Resources Engineer
morganmc@cdmsmith.com

CDM Smith
5041 Corporate Woods Drive,
Suite 250
Virginia Beach, Virginia 23462
757.318.9800

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