ASCE Workshop: Engineering Methods for Precipitation under a Changing Climate

Practicing Engineers and the Issue of Changing Climate

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May 30, 2017

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Outline

- Design Parameters and Climate Change
  - IPCC 2013; due for IPCC 2018 in Edmonton, Canada
- Traditional Role of a practicing engineer
- Emerging Climate Change Guidance
- Questions Engineers Have?
  - Is there non-stationarity?
  - Is it detected in some regions or national?
  - Will it affect design values we use?
  - What values should we use?
- Unified Approach – Answers/Solutions
- Case Studies - Climate Resilient Designs/ Analyses

Design Parameters and Climate Change

Hydrology

- Design Rainfalls
  - Atlas 14/ TP 40 etc.
- Design Discharges
  - Watershed modeling
    - Design rainfall to generate discharge of that frequency
    - Temporal distribution of storm
  - Stream Gauge Data
    - 17B/ 17C
  - USGS Regression Equations

Hydraulics

- Tailwater elevations
  - Sea level rise
- Tidal reaches
  - Joint occurrence of coastal/ inland rain event

Engineer- Trained Role vs Recent Role

- Take Federal/ State / community guidance
- Apply in the water resources design and analysis
- Take Responsibility for the safety of the design/ result

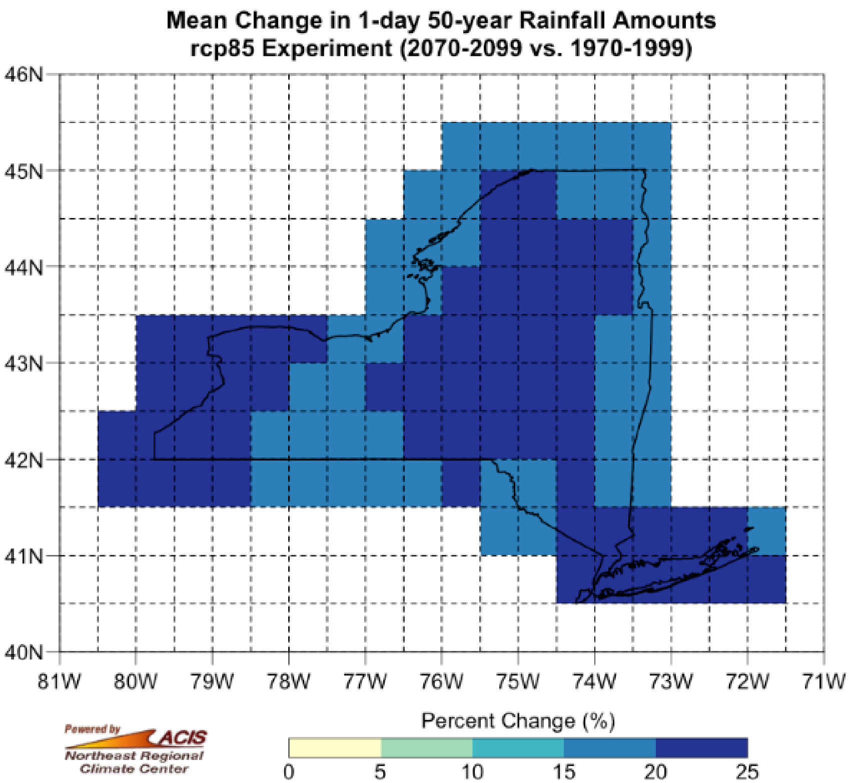
- After ‘Climate Change’ news
- Study the climate projections
- Understand down-scaling/ upscaling
- Study how design parameters were derived
- See how climate projections can be incorporated
- Produce results with lots of caveats to safe-guard professional integrity

Emerging Climate Change Guidance

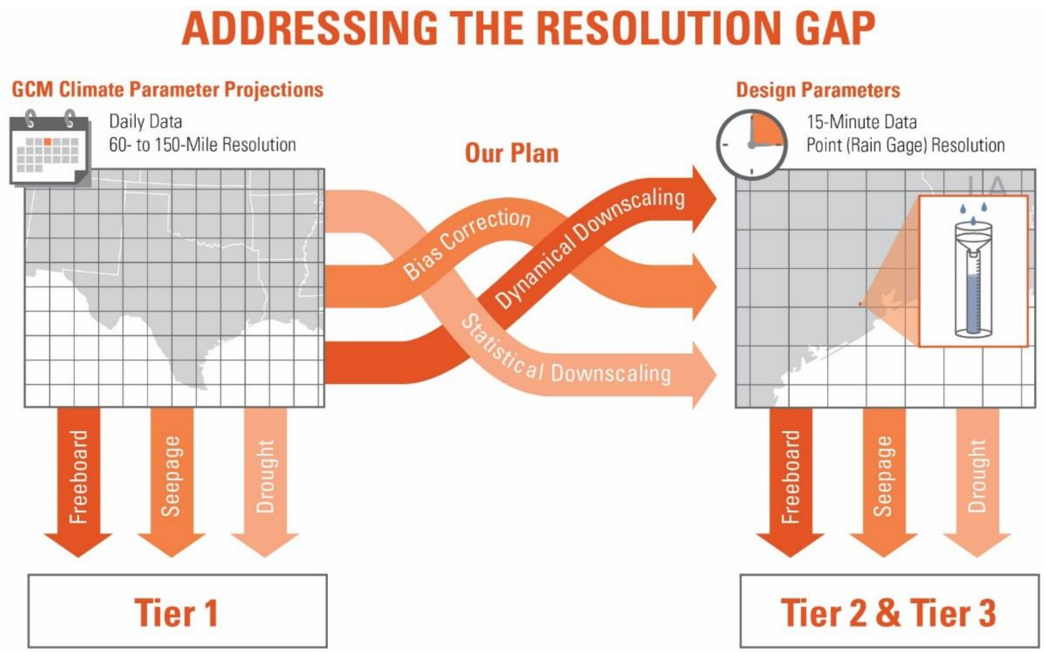
- Federal Guidance
  - USACE – Non-stationarity detection tool
  - EPA – SWMM-CAT
  - FEMA –Unpublished, Climate Regression Equations – HUC-2
  - USGS – NY climate Regression
  - NOAA/NWS
  - NRCS

State Effort

- IDFs for New York



Case Studies – Tiered Approach



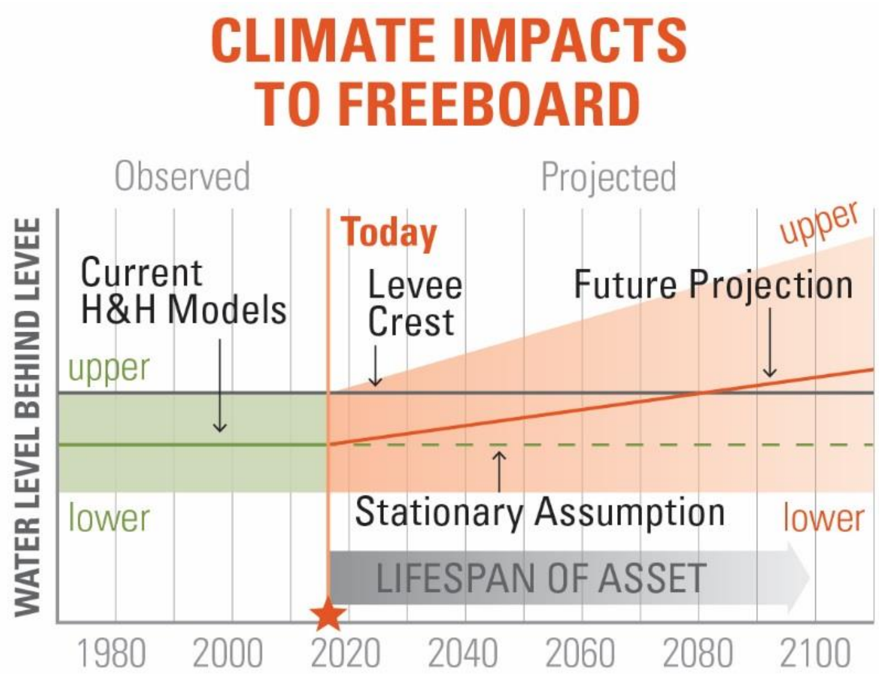
Evaluating existing structures

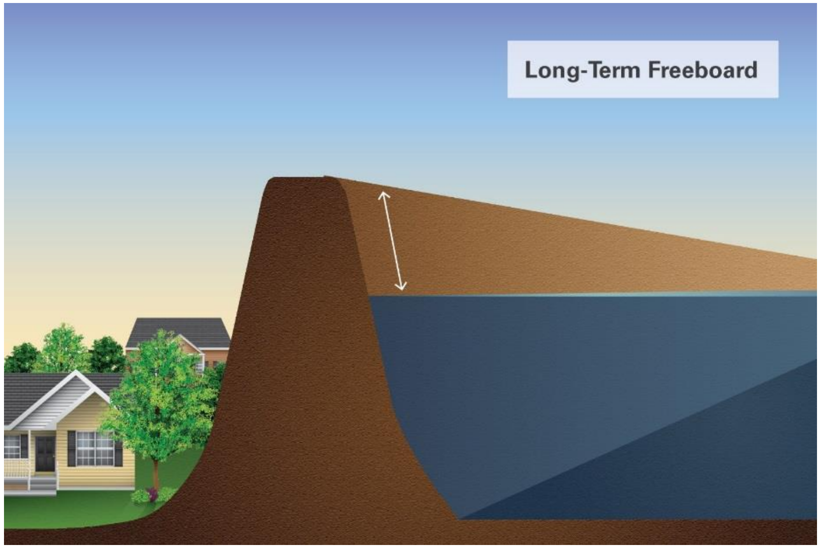
Tier 1 – Use GCM as is

Tier 2, 3, and 4 –

- No/ sparse guidance
- Method to integrate GCM with observation
- Develop new design parameters
- Defend the methodologies

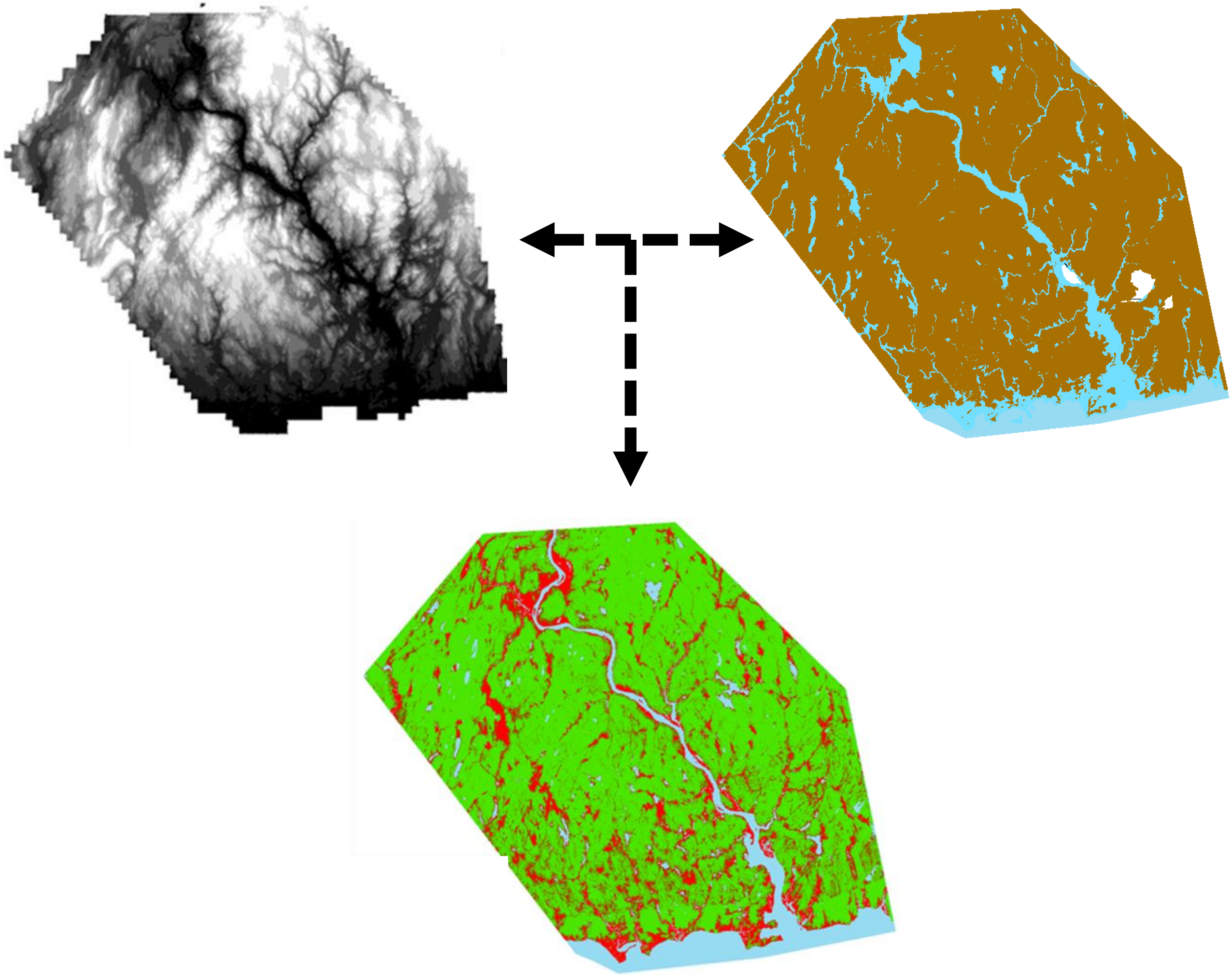
Case Studies – Levee Freeboard





Flood Susceptibility Analysis

1. Identify flood risk factors that apply to the region of interest.
2. Correlate these flood risk factors to flood inundation during a particular event.
3. Use resulting relationships to produce a flood susceptibility map.
4. Assess the potential impacts of climate change on flood frequency.



Flood Risk Factors

Land Cover (LAND)

Elevation (ELEV)

Land Slope (SLOPE)

Curvature (CURV)

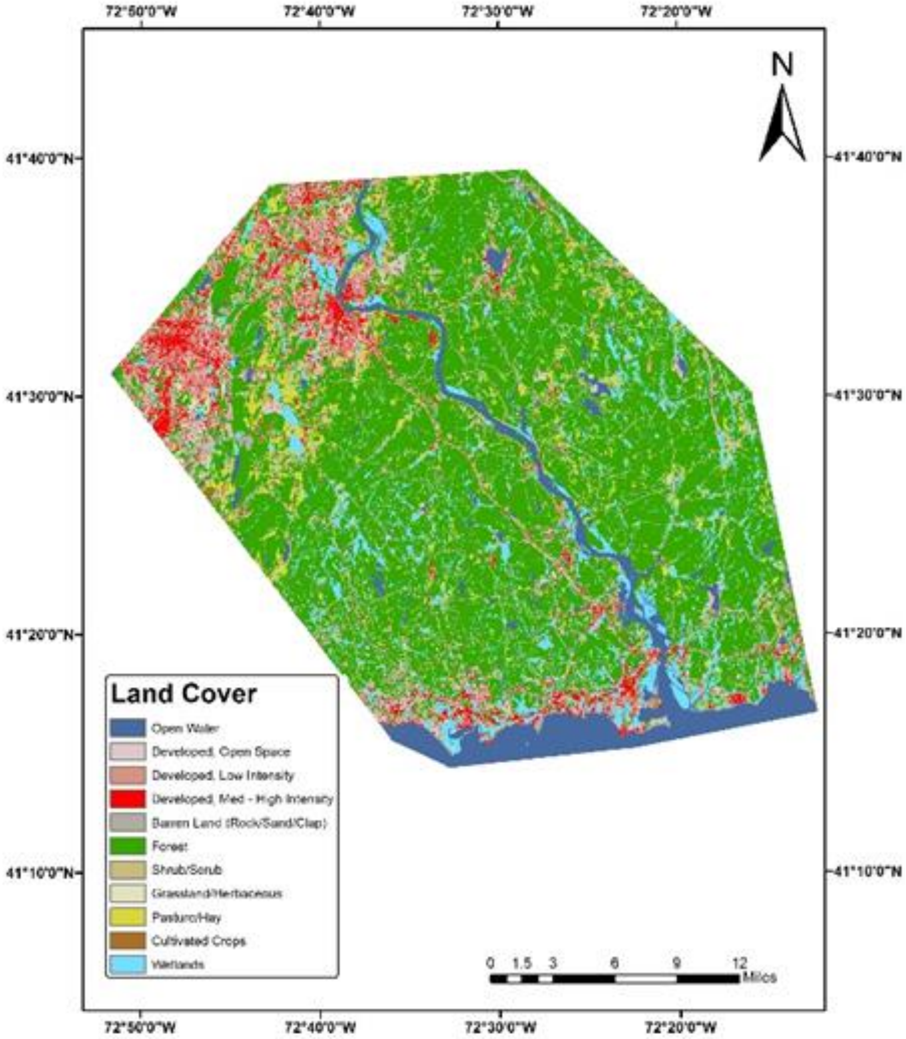
Distance from Water (DIST)

Soil Drainage (SOIL)

Vegetation Density (VEG)

Percent Impervious Surface (IMP)

Surface Geology (GEO)



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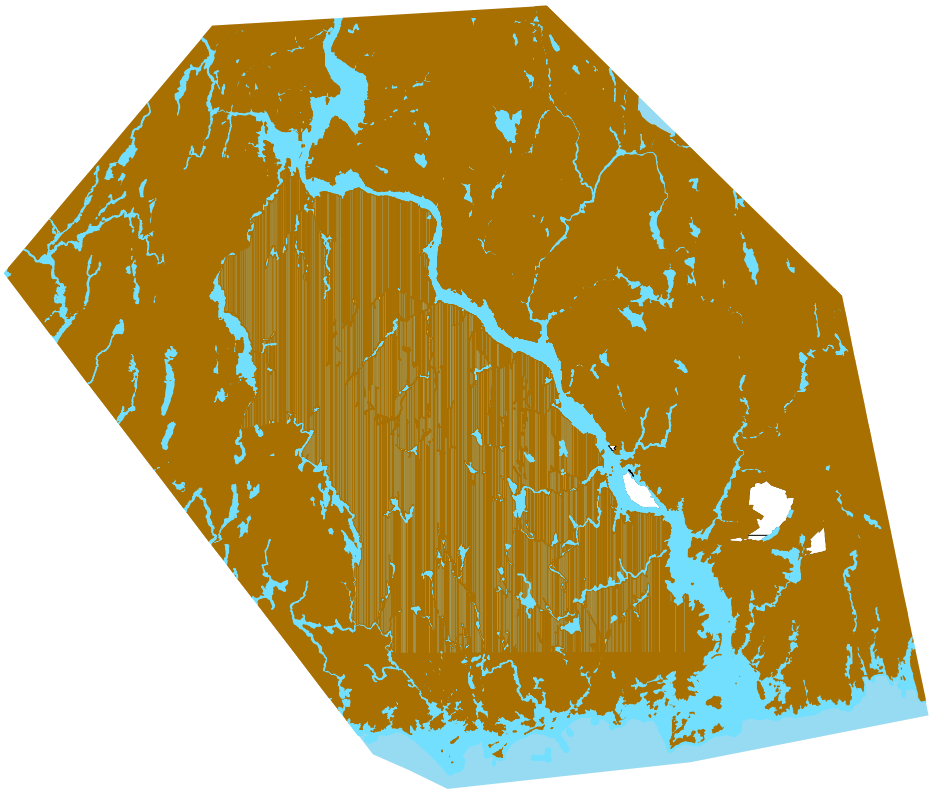
Select Flood Event(s)

- Satellite images could not be used:
  - Very poor quality over a 5 to 10 year period
  - Only available for events with < 25-year recurrence

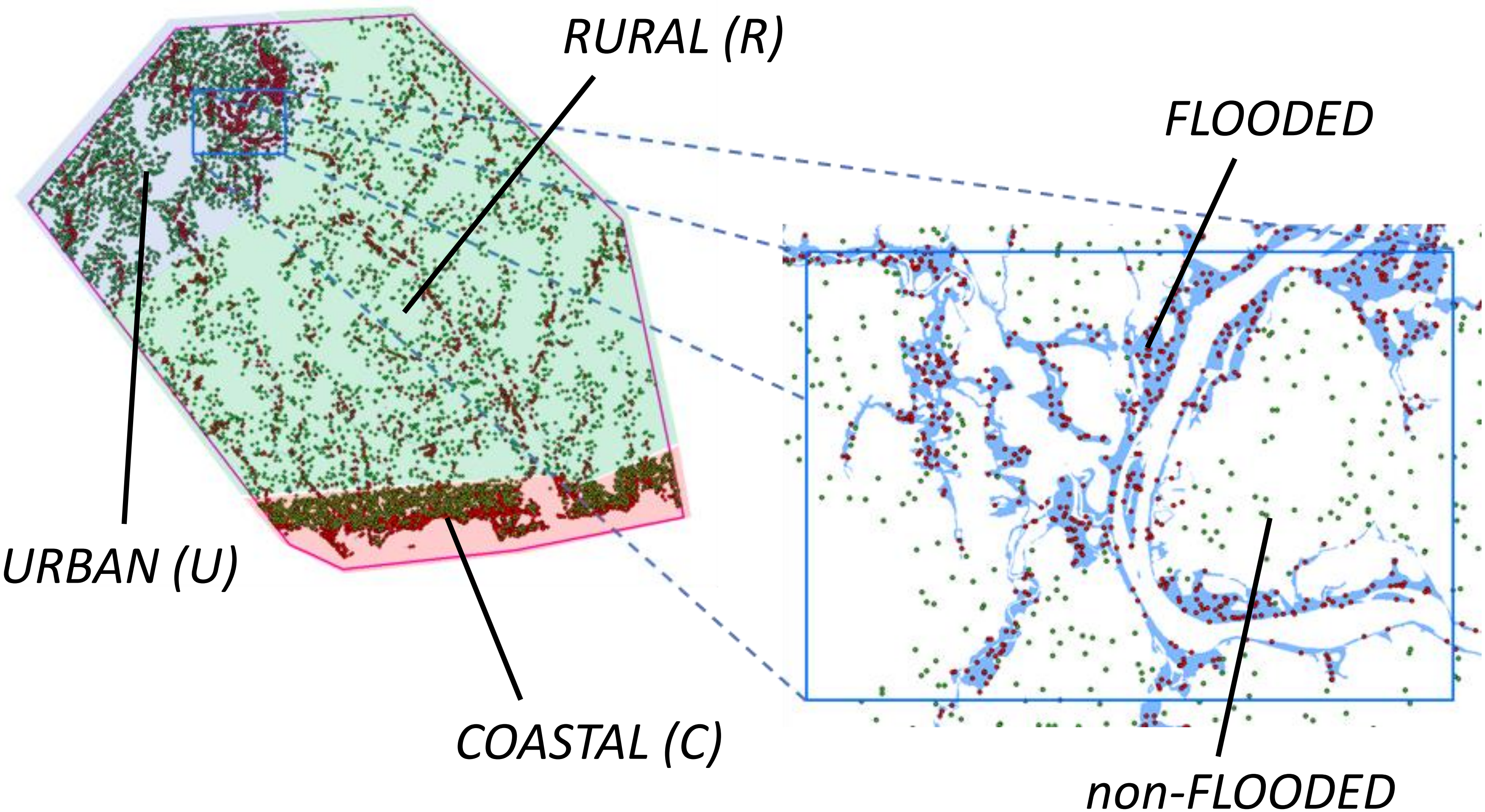
- FEMA 100-year floodplain used

- Correlation between flood risk factors and flooding is what we want to obtain.

- Ideally 2 to 3 events would provide ability to interpolate.



Regionalization and Sampling Points



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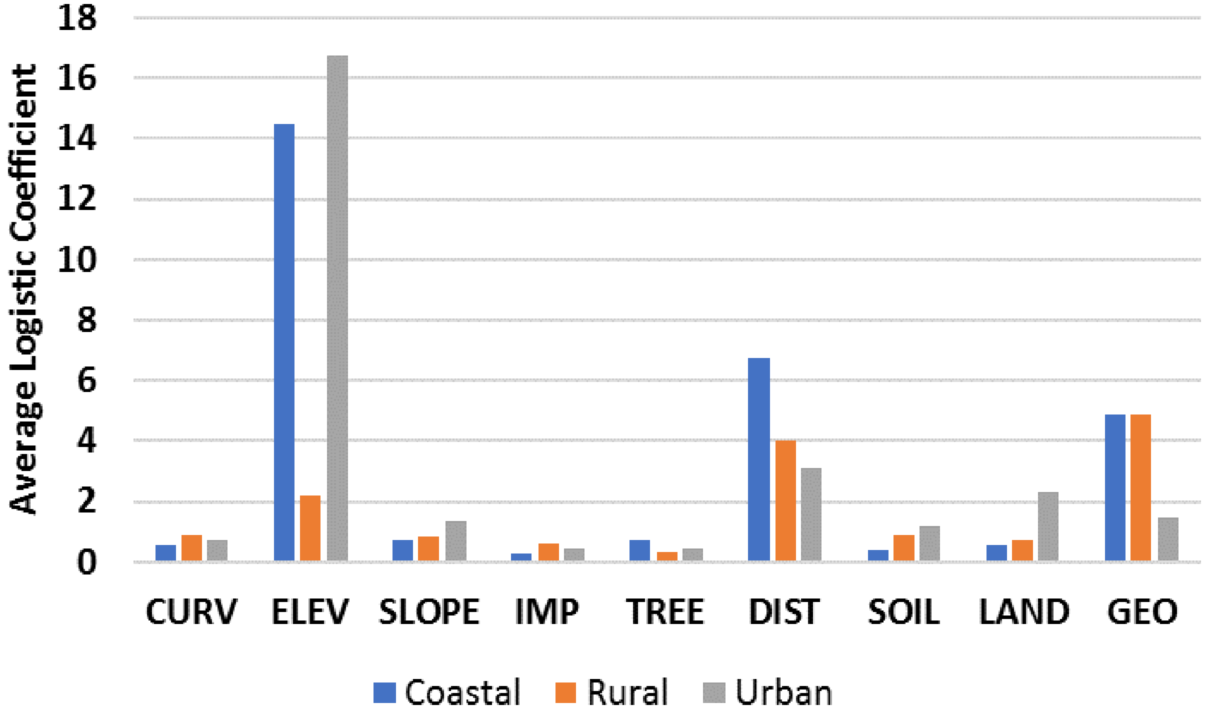
Relative Contribution of each Factor

- Average magnitude of model coefficients for each sub-region.
- **Elevation** & **distance to water** contribute most in coastal & urban sub-regions. **Land Cover** is a close third in the more urban sub-region.
- **Surficial materials** & **distance to water** contribute most in rural sub-region
- **Vegetative density,** and **land curvature** have little impact in all regions.



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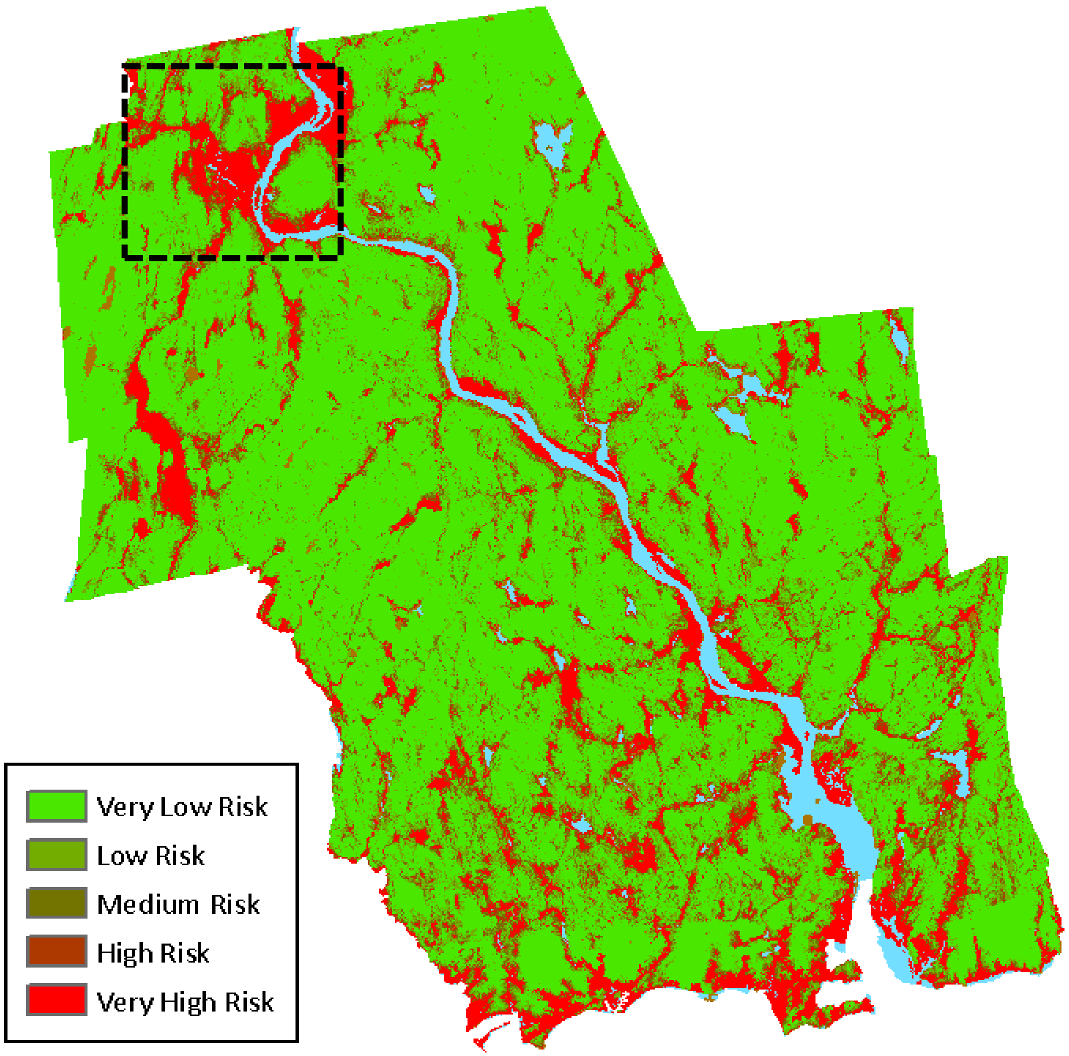
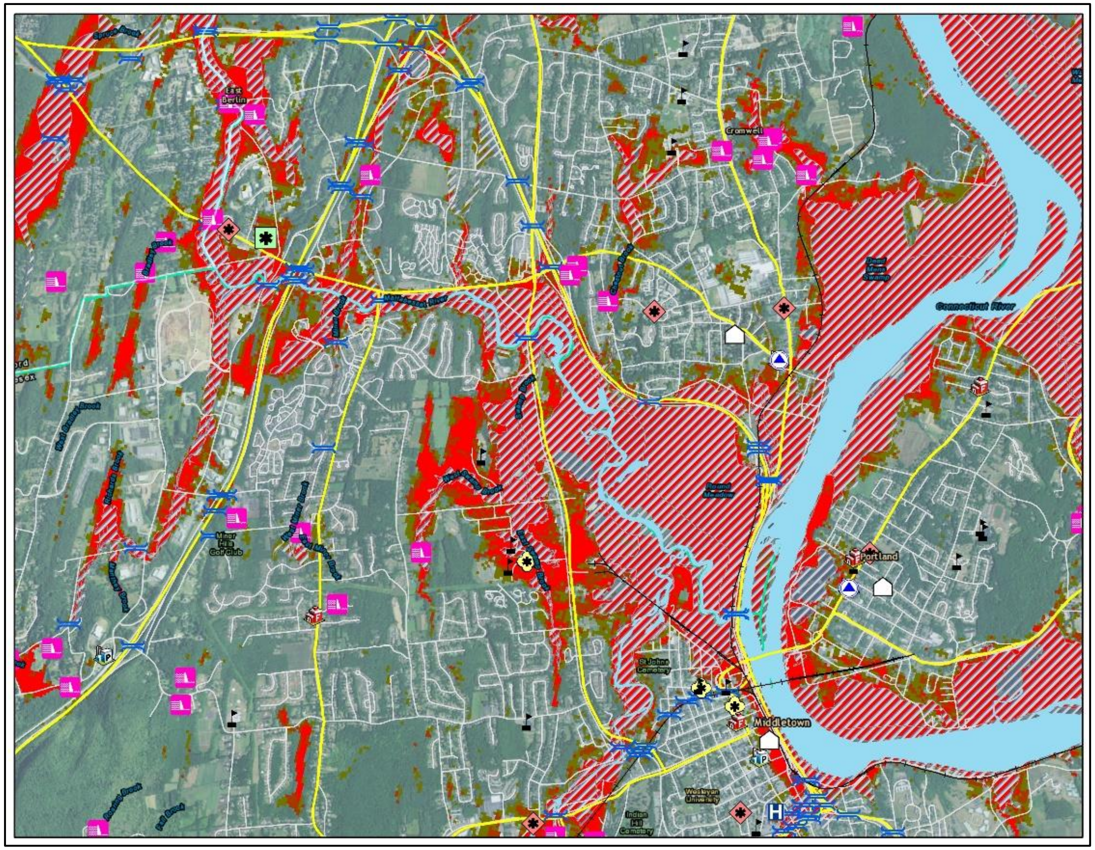
Flood Susceptibility Map

- Using logistic regression, the probability of inundation is obtained for every point in the "Area of Influence", values are categorized according to the following:
  - **Very Low Risk**: 0 – 20%
  - **Low Risk**: 20 – 40%
  - **Medium Risk**: 40 – 60%
  - **High Risk**: 60 – 80%
  - **Very High Risk**: 80 – 100%



Comparison to FEMA Map (Urban)

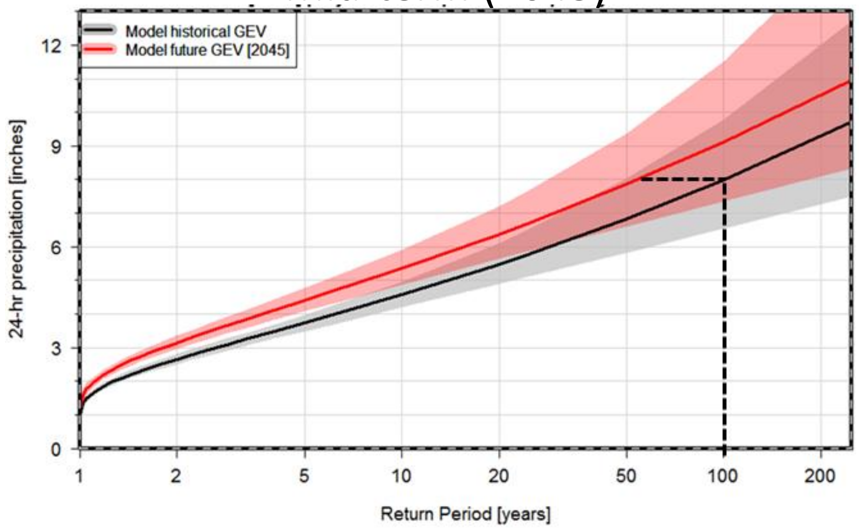
- Large areas of susceptibility are not included in the FEMA map.
- **It should be noted that the susceptibility map <u>should not be used for regulatory or insurance purposes</u> in place of the FEMA map, but is only a tool that can be used for planning purposes.**



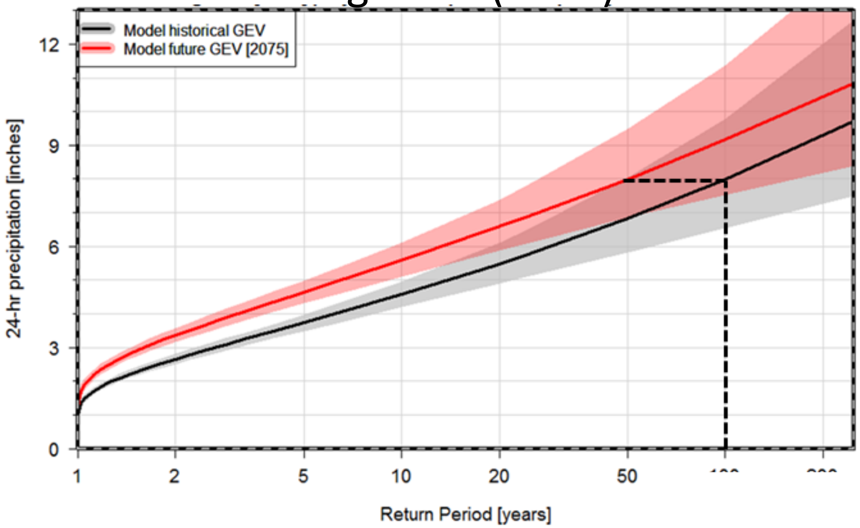
Impacts of Climate Change

- 24-hour rainfall for frequencies up to 1 in 200 years is plotted for the historical period of 1950 – 2005 in black and for mid-term (2026 - 2065) and long-term (2056 - 2095) periods in red.
- Gray and pink shaded areas represent uncertainty bounds.
- Example: Today's 100-year 24-hour rainfall event will become a ~55-year event in 2045 and a ~45-year event in 2075.
- Projections from the North American Coordinated Regional Climate Downscaling Experiment (NA-CORDEX) using only simulations with the highest resolution (11 km, 7 mi).

Mid-term (2045)



Long-term (2075)



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Summary

- Summary of Emerging published Federal and State Guidance
- Typical cases where engineers are formulate climate change impact evaluation and incorporation are discussed
- Engineers need guidance to address climate change.
- Alternative methodology for flood susceptibility mapping was presented that can significantly reduce the cost compared to similar FEMA analyses.
- Flood susceptibility map showed a wider area susceptible to flooding than FEMA flood map (though FEMA map show still be used for regulatory and insurance purposes)
- Model projections predict greater increases in more frequent events when compared to less frequent events by 2045 and 2075.