MAINE WATER CONFERENCE

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Designing Infrastructure for an Uncertain Future: Assessing Lifecycle Costs of Culvert Designs

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Living in a Changing Climate

- Construction costs for larger structures are generally more expensive than replacing in kind → limits the number of projects that can be undertaken over time

- Is this trade-off simply the price we pay for living in a changing climate?

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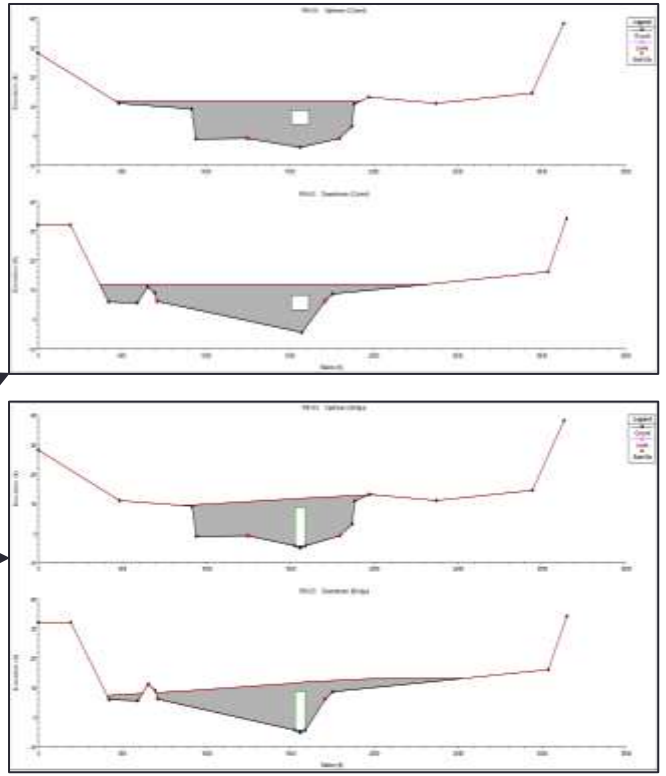
Pilot Project: Middle River Bridge, Machias Causeway

- Tested two design options for the aging causeway tidal gates against damages from storm surge and sea level rise to calculate lifecycle costs
  - Replace with box culvert
  - Replace with single span



Bridge Design	Damages ($1000)	Bridge Cost ($1000)	Total Costs ($1000)
Box Culvert	607.3	2,200	2,807.3
Single Span	862.8	2,400	3,262.8

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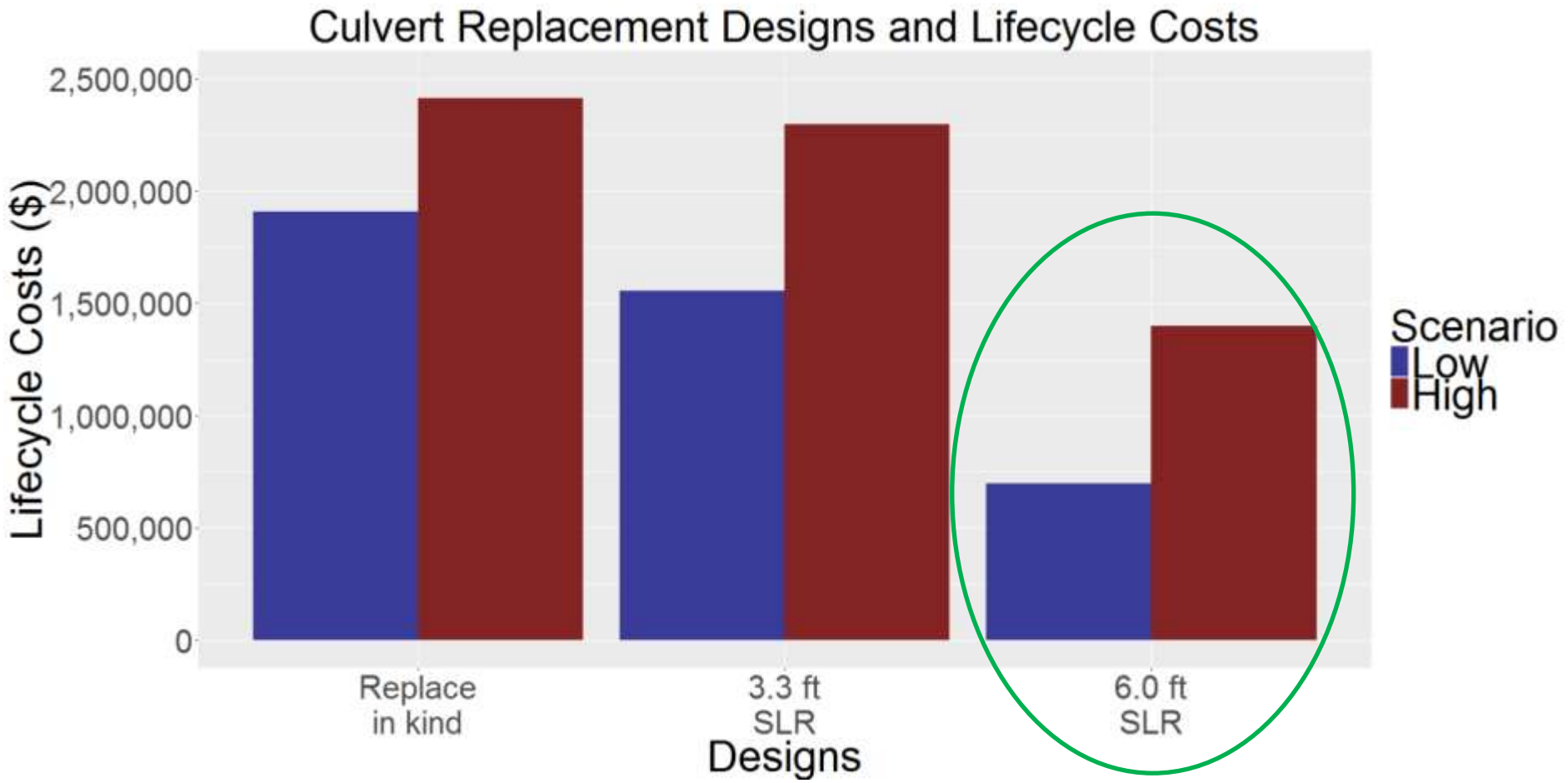
Pilot Project: Scarborough and Bowdoinham Culverts, Bath Bridge



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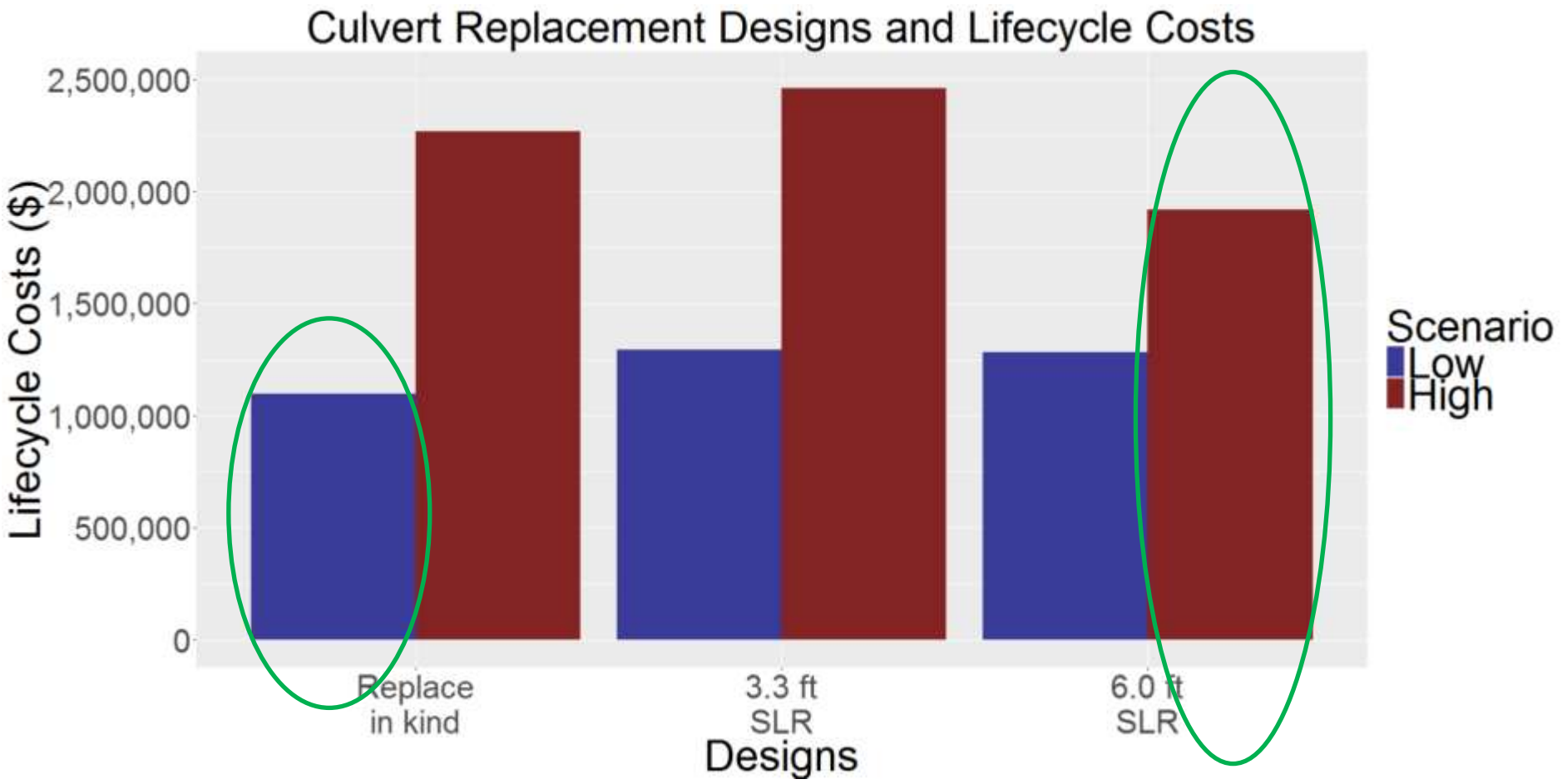

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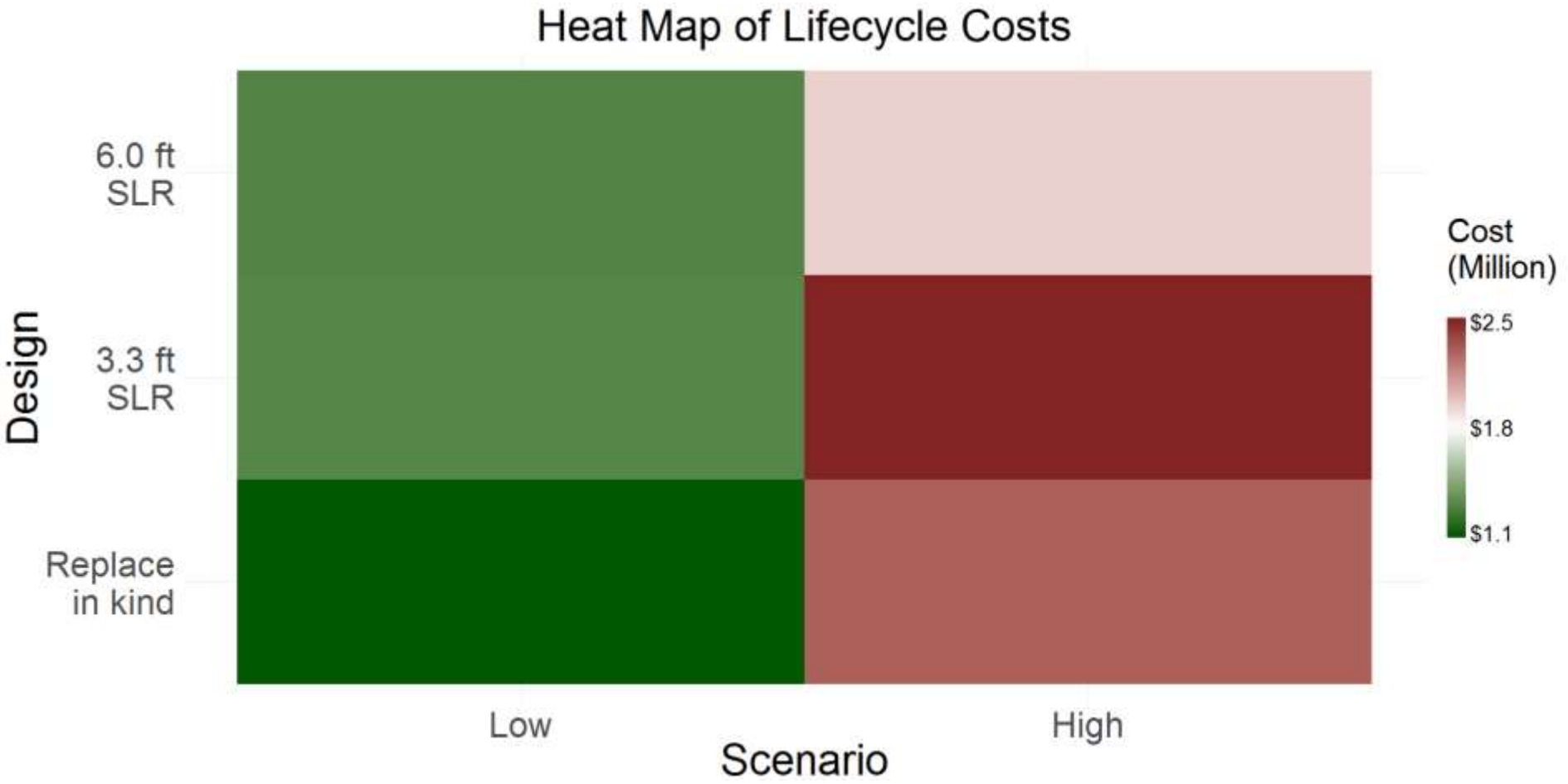

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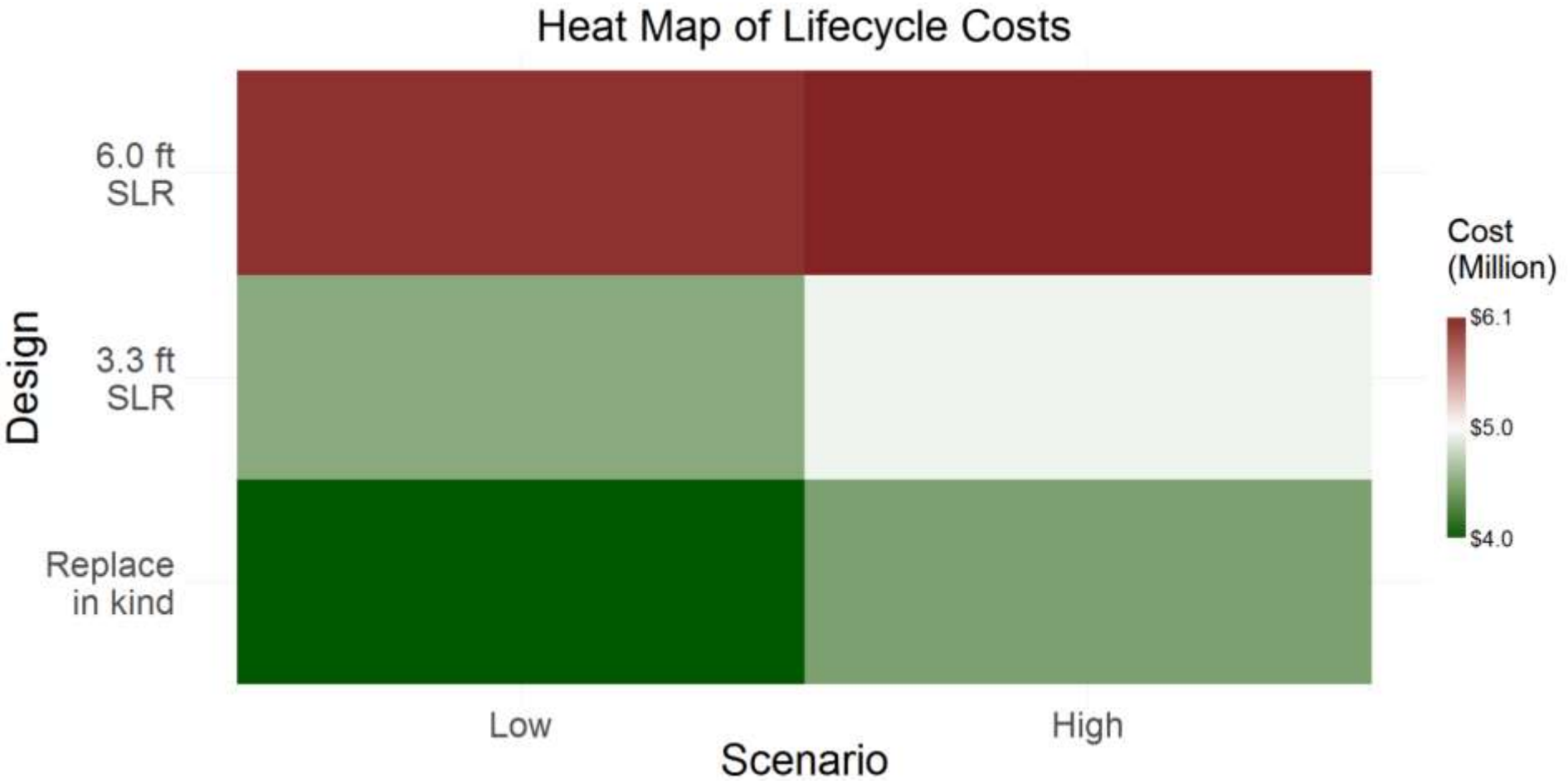

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Calculating Lifecycle Cost

- Lifecycle cost =

  construction cost

  + potential damages over time

- Construction costs → MaineDOT
- Potential damages → Sea level rise curves, depth-damage functions and exceedance curves

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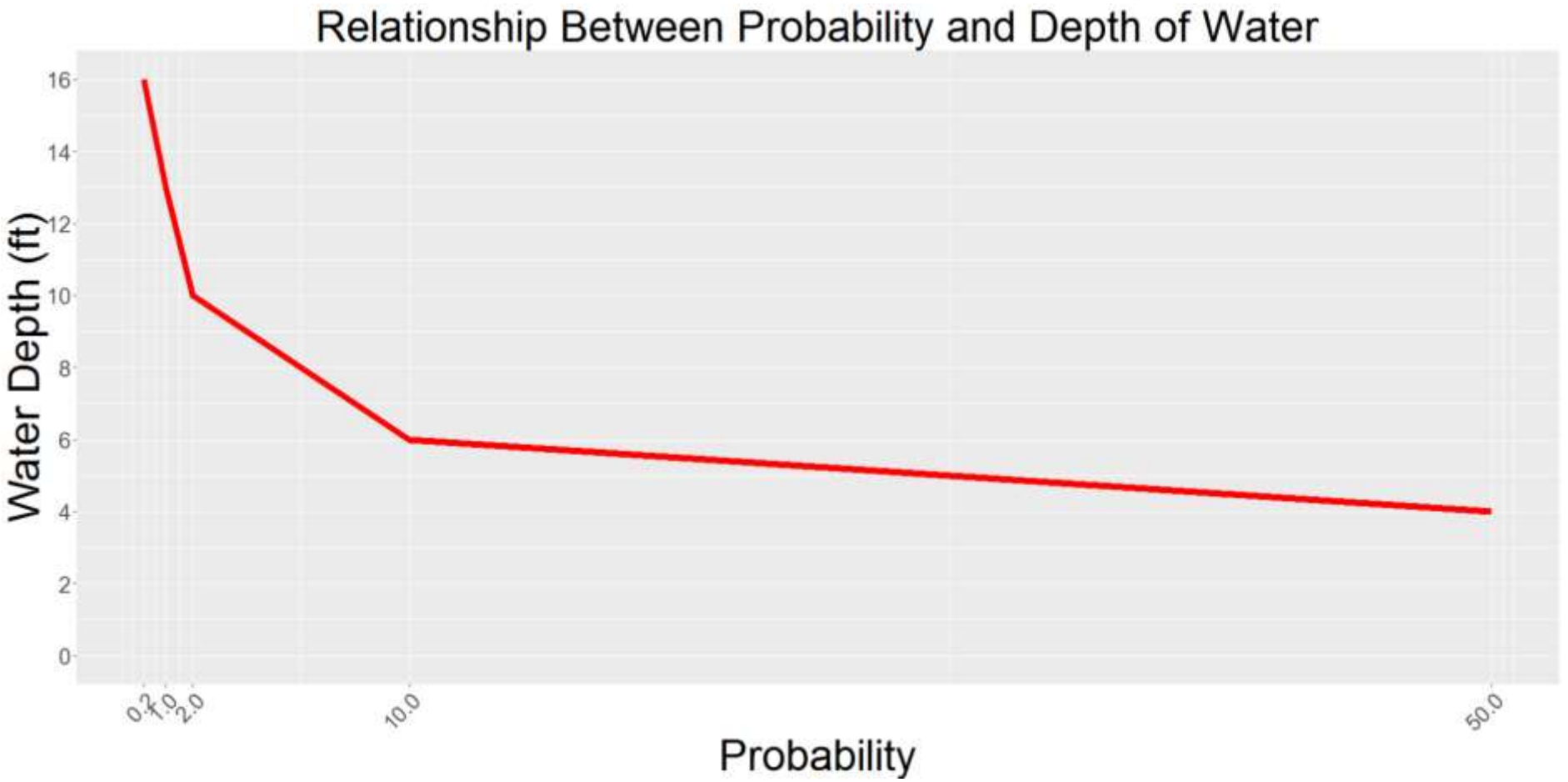
Storms and Probability



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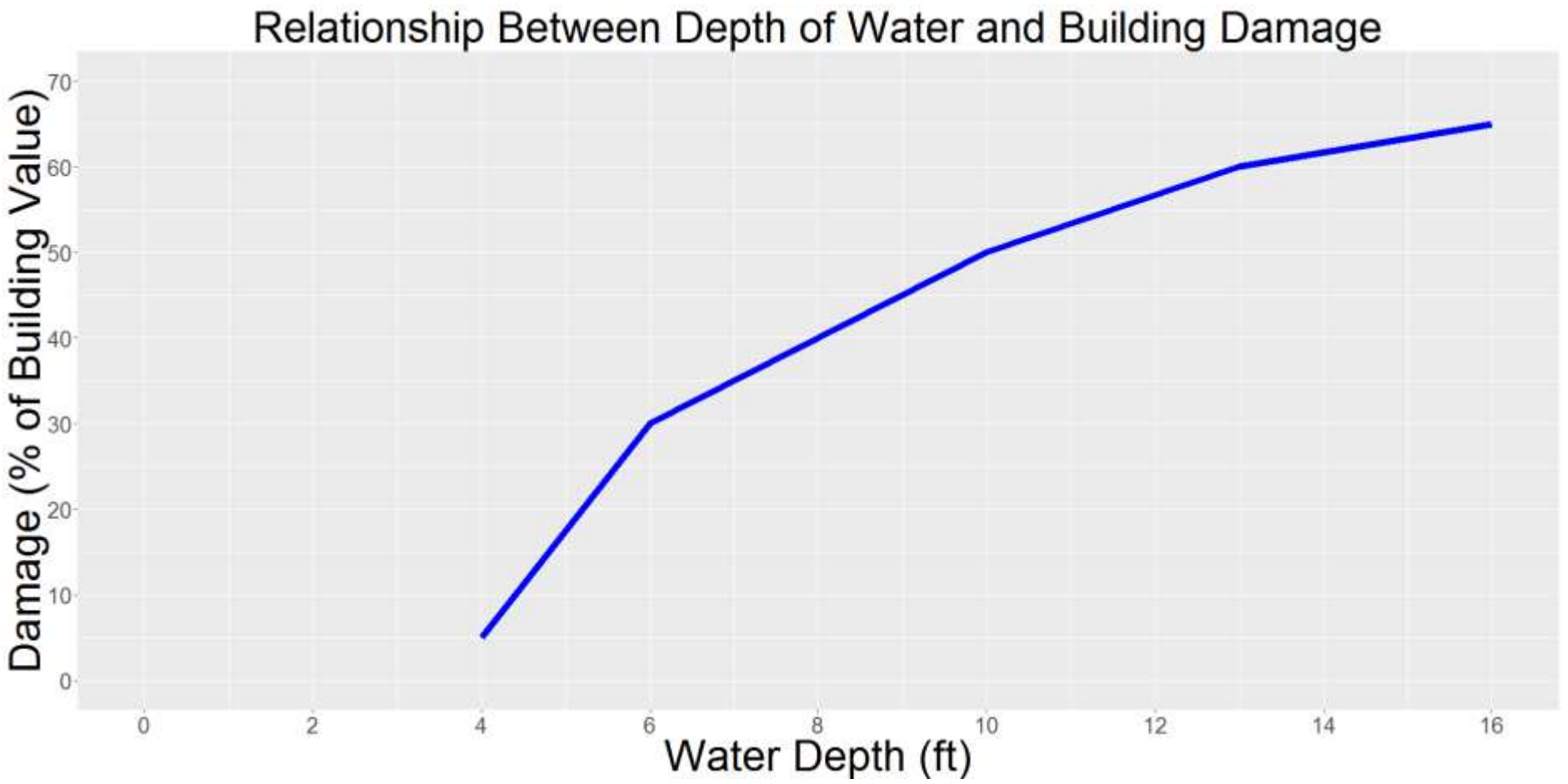
Depth-Damage Functions



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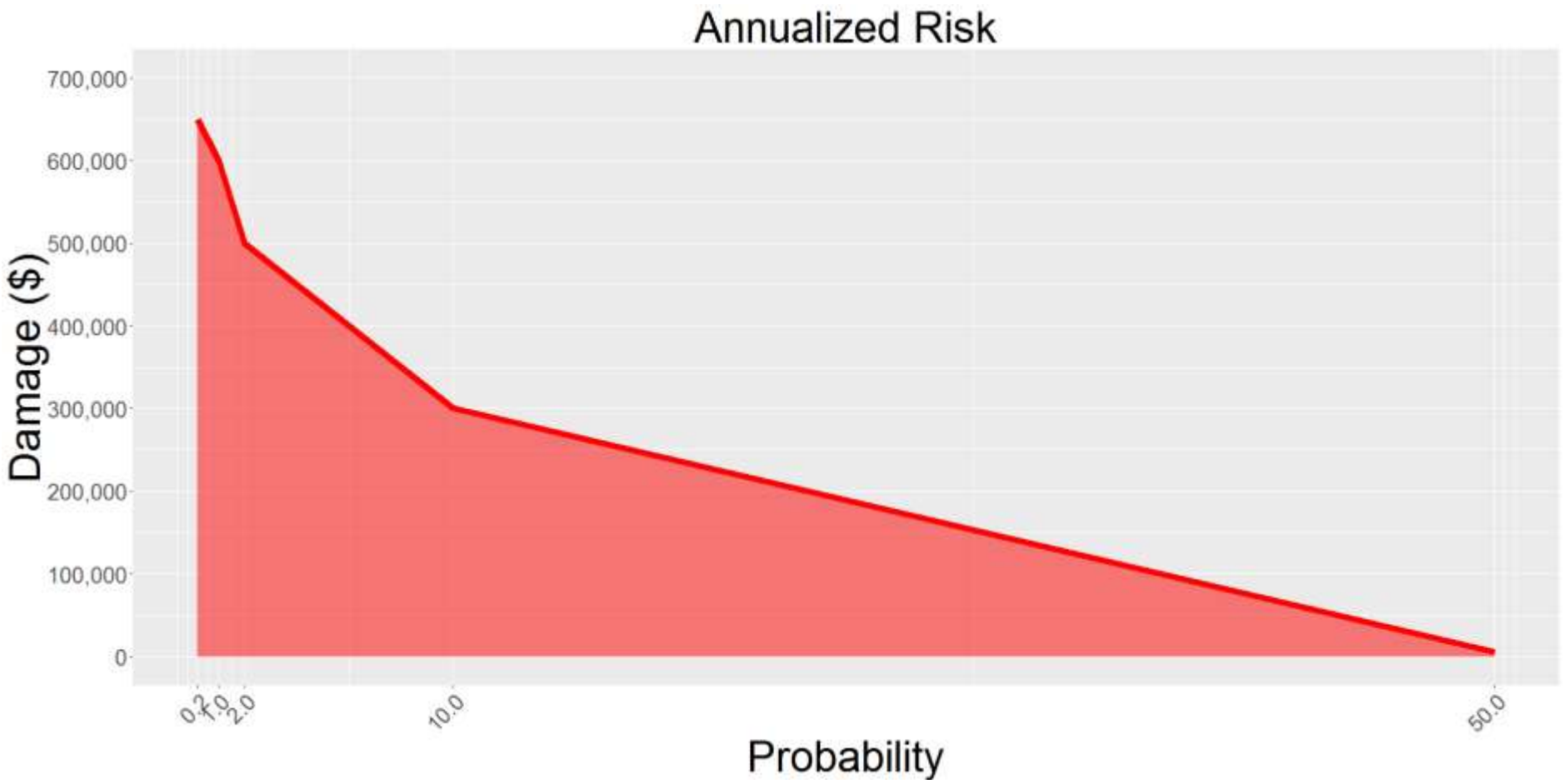
Annualized Risk



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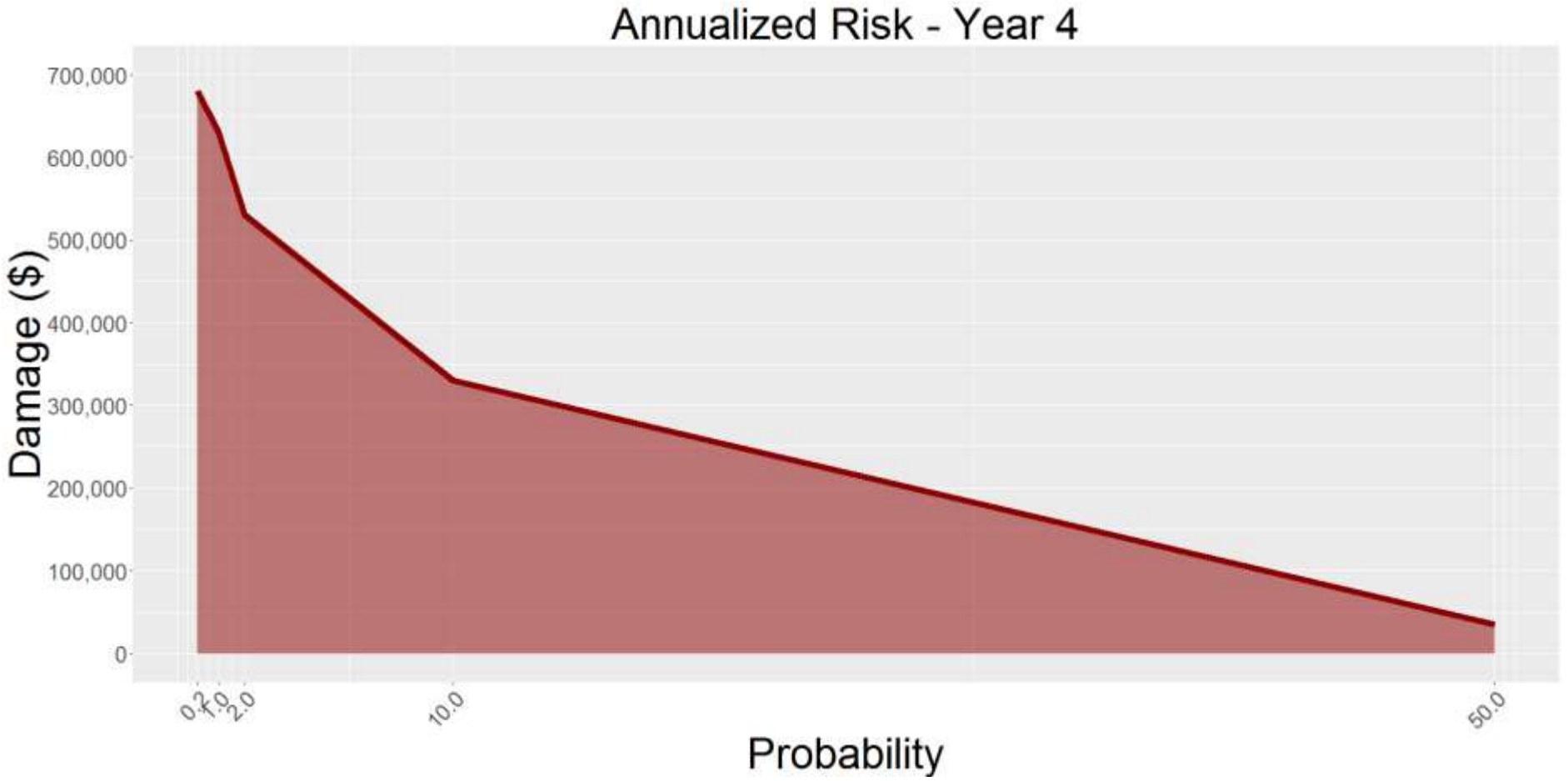
Adding Sea Level Rise



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Analyzing Culverts Based on Increased Flows

- Test 3 climate scenarios:
  - Low (no change)
  - Medium (increased runoff by 24%)
  - High (increased runoff by 52%)
- Test 3 design types:
  - Q100
  - Q100 + 24%
  - Q100 + 52%
- Calculate lifecycle costs (construction + damage over time)

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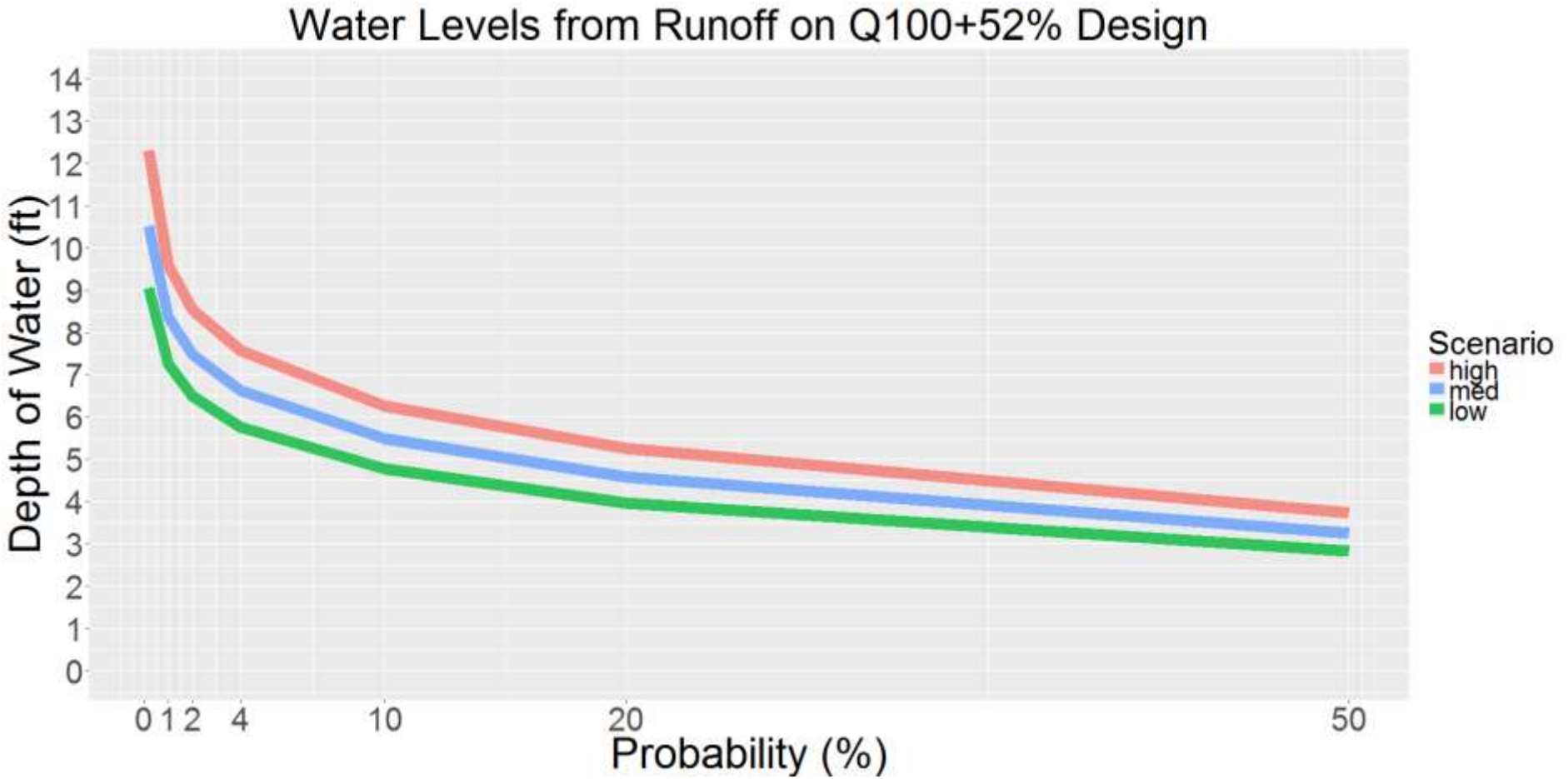
Analyzing Culverts Based on Increased Flows



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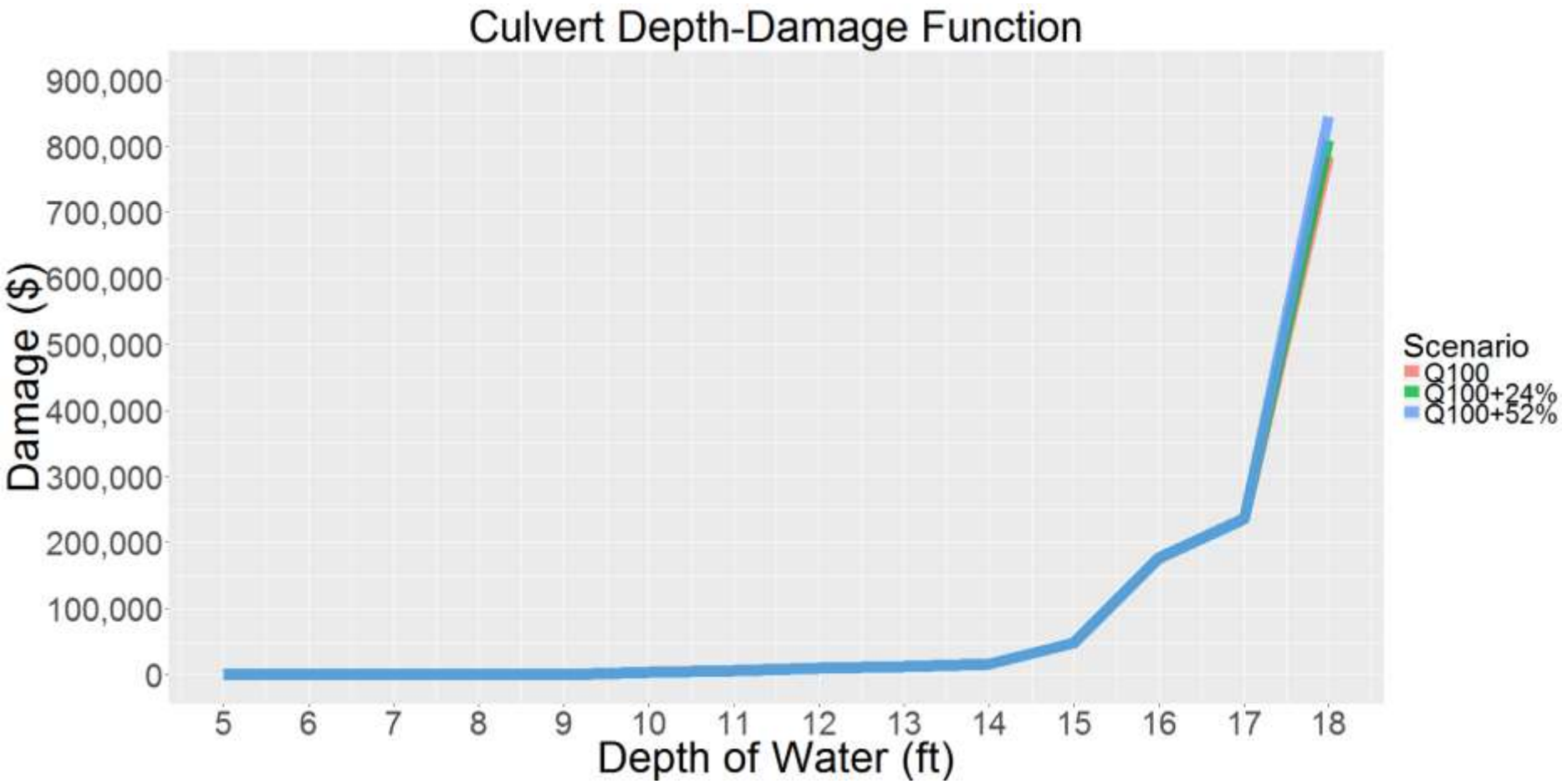
Culvert-specific Depth-Damage Functions



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Results

- Designing for today's 100-year event was the most robust design across all climate scenarios

- MaineDOT wanted to check the results using a Q25 design…

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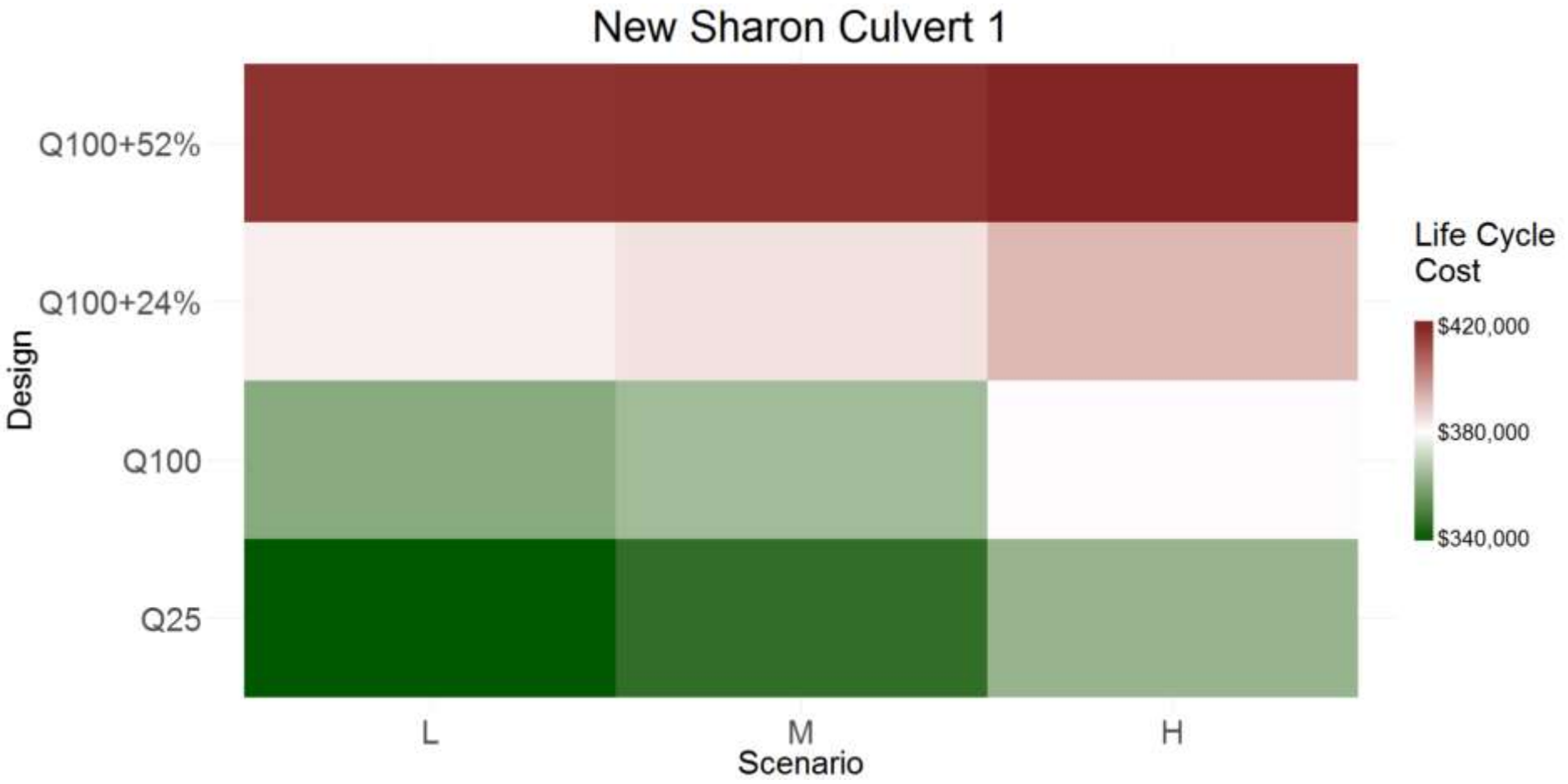
Results



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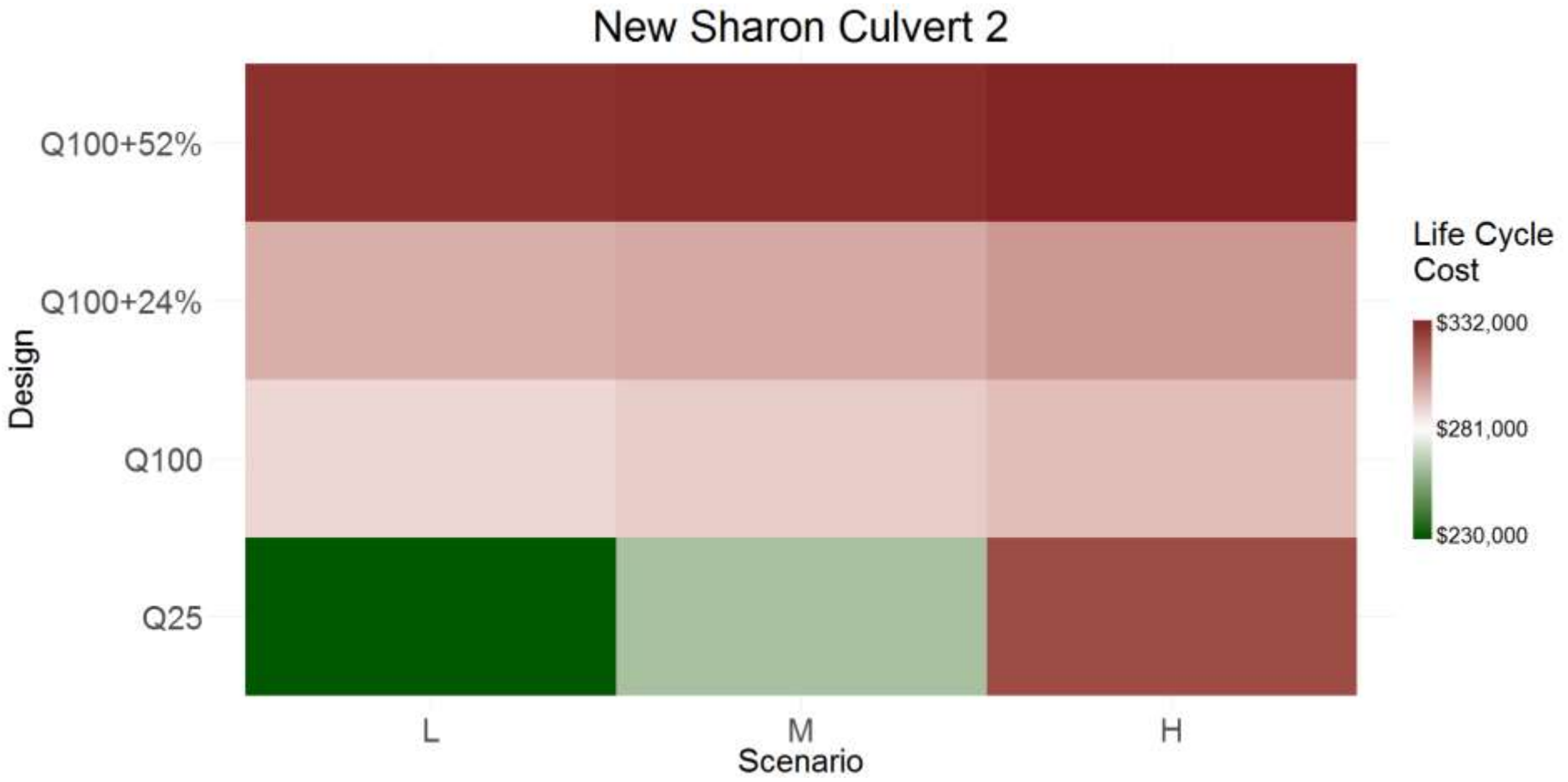
Results



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Implications

- MaineDOT is NOT going to downsize culverts
- MaineDOT does NOT have to upsize all culverts
- Strategic opportunities to keep costs low in order to replace more aging infrastructure

- “All models are wrong – some models are useful.”
  - Is this a useful model?
  - If not, how could it be improved?

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Improving the Model

- Public sentiment cost
- Added cost for replacing in kind if not environmentally friendly
- Calibrating model with water surface elevations and updated repair costs after storms

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Summary

- Is the trade-off of addressing fewer culvert replacement projects in order to increase culvert sizes simply the price we pay for living in a changing climate?

- It is if we decide to increase the size of every culvert…
  - Results from this study show that we can be more strategic with our culvert improvements → larger culverts not always the best design

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Summary

- Is the trade-off of addressing fewer culvert replacement projects in order to increase culvert sizes simply the price we pay for living in a changing climate?

- It is if we decide to increase the size of every culvert…
  - Results from this study show that we can be more strategic with our culvert improvements → larger culverts not always the best design

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