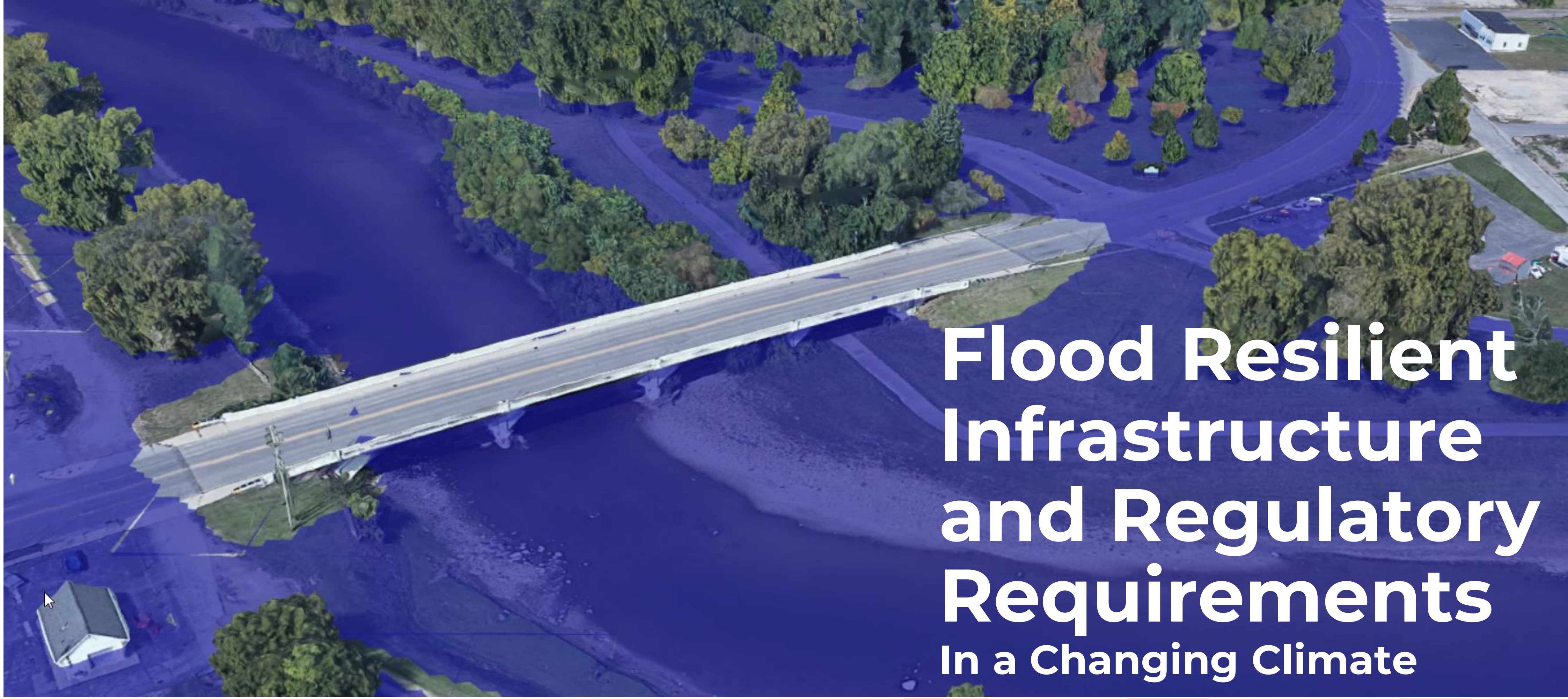

Flood Resilient Infrastructure and Regulatory Requirements

In a Changing Climate

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Illinois Association for Floodplain and Stormwater Management Conference

Tinley Park, Illinois

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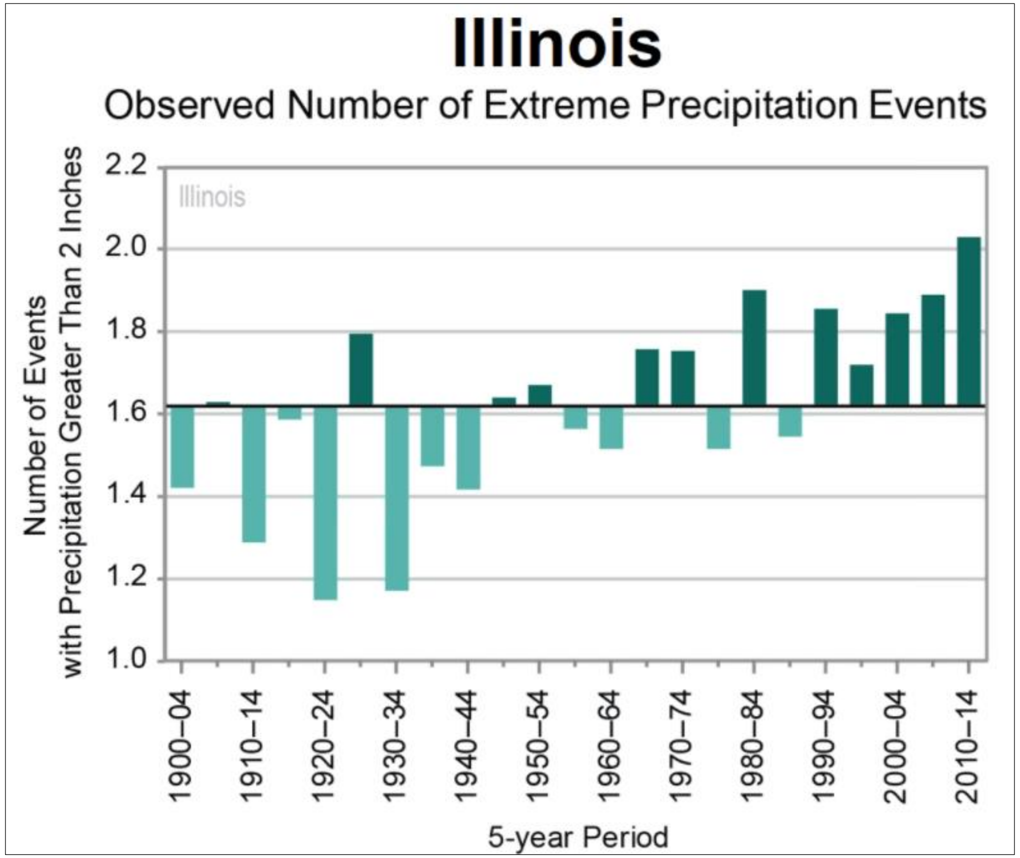
Overview

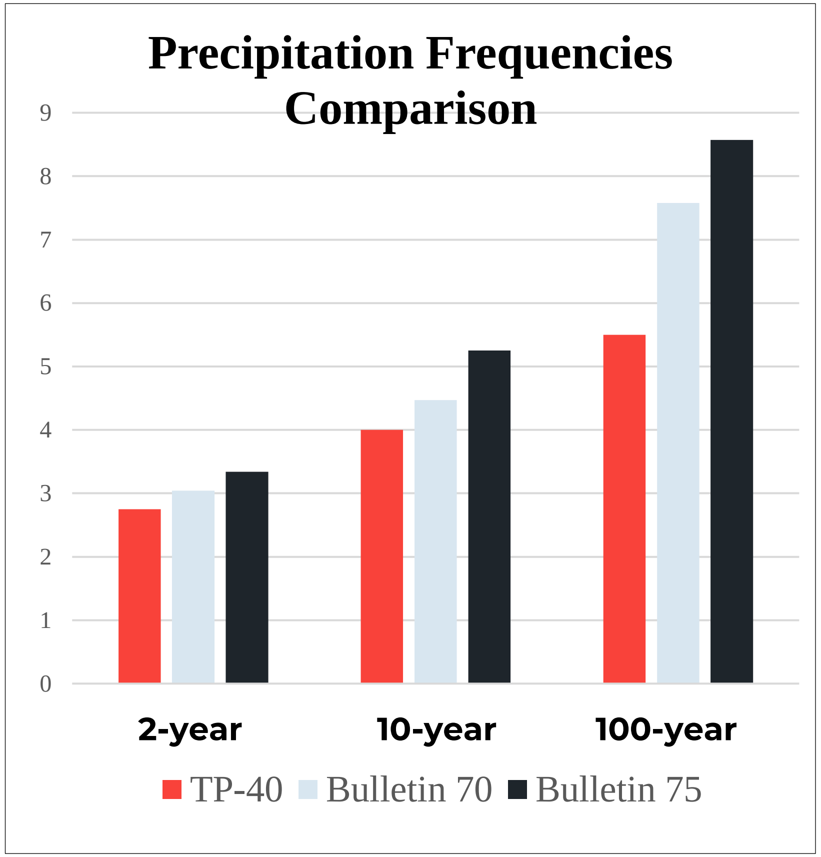
- Precipitation Data
- Challenges
- Design Principles
- Climate Model Tools
- Solutions and Resilience
- Regulatory Requirements

Precipitation Data

Precipitation Data

Heavy rainfall and design frequencies have been increasing over the past 50 years.





Source: Illinois State Water Survey

Challenges

Challenges

Engineering design uses historic data to design infrastructure expected to persist for 25 to 100 years in the future.

Our climate is non-stationary. Past records do not contain all the possibilities of extremes or trends of the future.

This is the equivalent of only using the rear-view mirror when driving forward.

Design Principles

Design Principles

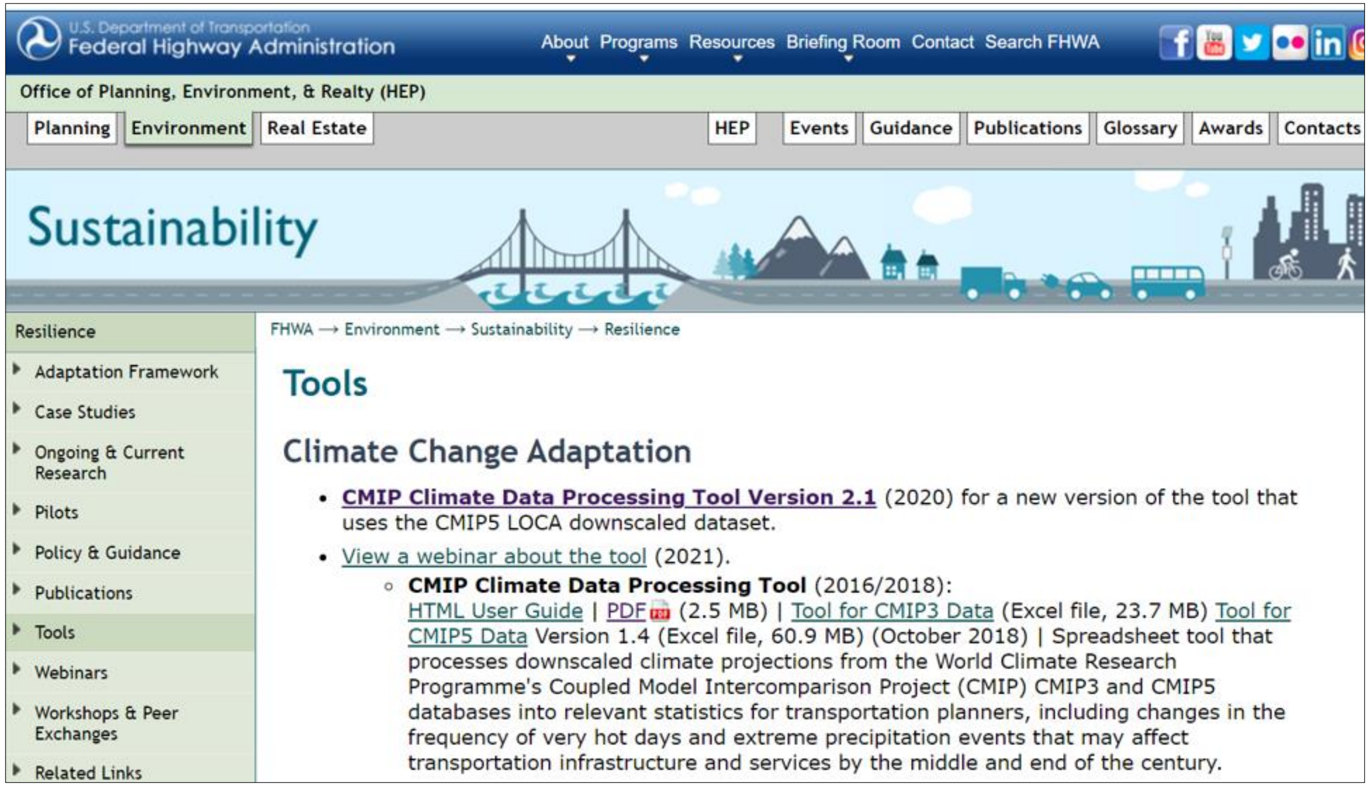
To create climate resilient infrastructure, engineers can use climate model projections to evaluate how future precipitation trends will impact infrastructure.

Design life: how many years we expect infrastructure to function.

Infrastructure	Design Life (years)	Climate Projection (year)
Buildings	100	2100
Roads (major) and bridges	50	2070
Roads (minor) and parking lots	25	2050
Sewers	75	2100

Climate Model Tools

Climate Model Tools



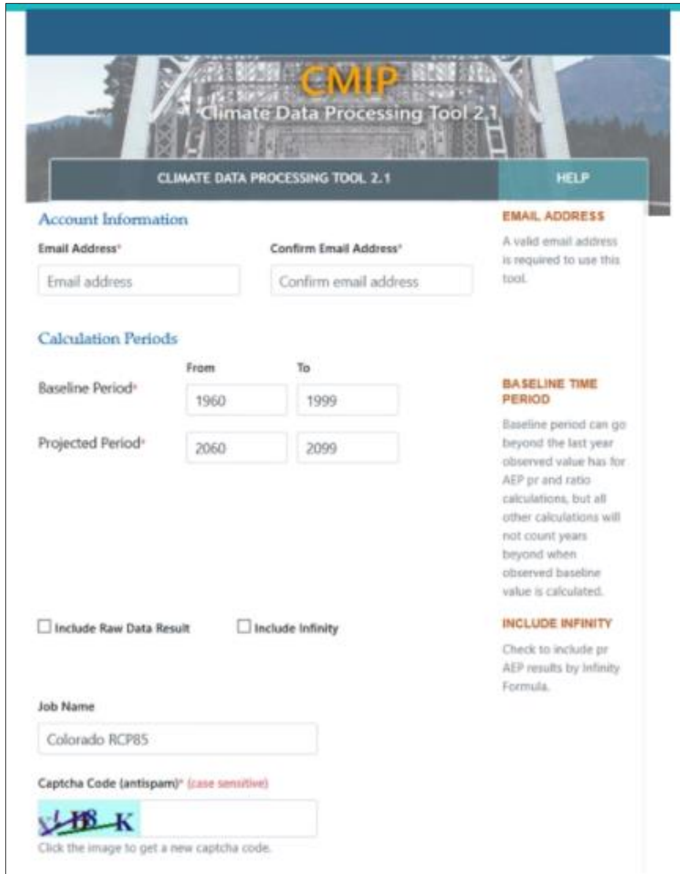
Future conditions precipitation data

- Federal Highway Administration (FHWA) Coupled Model Intercomparison Project (CMIP) tool
- 21 climate scenarios for CMIP5

Source: FHWA https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/

Climate Model Tools

Example of CMIP output

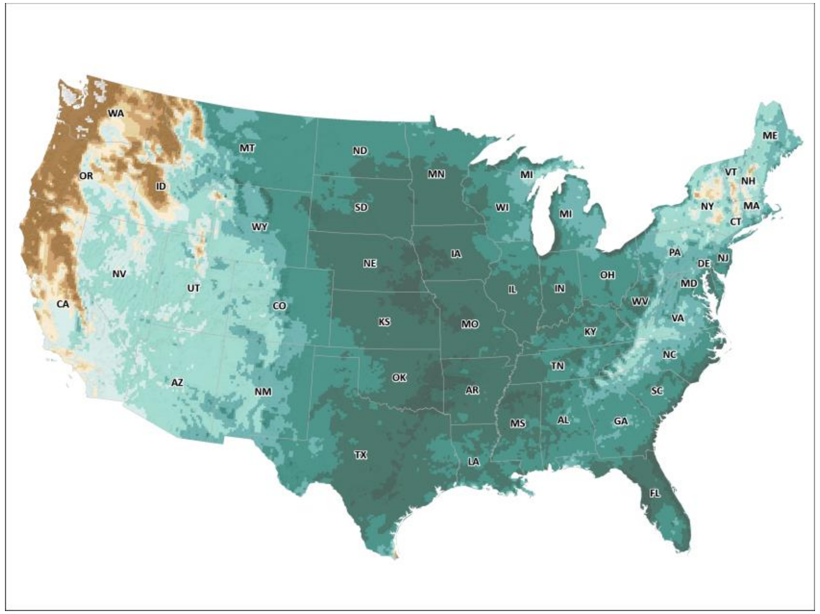


		Unit	Observed Value - Baseline Period (1960 - 1999)	Projection Value - Projection Period (2060 - 2099)
	Precipitation			
46	Average Total Annual Precipitation	Inches	16.40	16.79
47	"Very Heavy" 24-hr Precipitation Amount (defined as 95th percentile precipitation)	Inches	0.55	0.60
48	"Extremely Heavy" 24-hr Precipitation Amount (defined as 99th percentile precipitation)	Inches	1.21	1.30
49	Average Number of Baseline "Very Heavy" Precipitation Events per Year	times	5.83	6.37
50	Average Number of Baseline "Extremely Heavy" Precipitation Events per Year	times	1.18	1.40

Source: FHWA https://www.fhwa.dot.gov/environment/sustainability/resilience/tools/

Climate Model Tools

Argonne National Laboratory: Risk & Resilience Portal (ClimRR)



Precipitation (inches) - Difference in Annual Total – End-Century RCP4.5 and End-Century RCP8.5

Source: www.anl.gov/ccrds/ClimRR/

ClimRR Report for Precipitation

Precipitation is any liquid or frozen water that forms in the atmosphere and falls back to the Earth. All values are calculated as 24-hour periods.

This report refers to: **41.78, -88.24**

Mid-Century Precipitation Analysis: The historical annual total precipitation is **31.17 inches**. Under RCP 8.5 the annual minimum precipitation at mid-century is **35.81 inches** which represents a **4.64 inch** change from the baseline.

Mid-Century Precipitation Analysis, Days Without Measurable Precipitation: The historical longest consecutive number of days without precipitation **24.00 days**. Under RCP 8.5 the longest stretch of days without precipitation at mid-century is **24.33 days** which represents a **0.33 day** change from the baseline.

End-Century Precipitation Analysis: The historical annual total precipitation is **31.17 inches**. Under RCP 8.5 the annual minimum precipitation at end-century is **38.63 inches** which represents a **7.45 inch** change from the baseline.

End-Century Precipitation Analysis, Days Without Measurable Precipitation: The historical longest consecutive number of days without precipitation **24.00 days**. Under RCP 8.5 the longest stretch of days without precipitation at end-century is **19.67 days** which

Climate Model Tools

US Army Corps' Strategic Environmental Research and Development Program (SERDP) Intensity-Duration-Frequency Curve tool

PRECIPITATION FREQUENCY ESTIMATES (in inches), Year: 2055, Scenario: RCP45

These values are for research use only.

csv

Location: Wheaton, Illinois

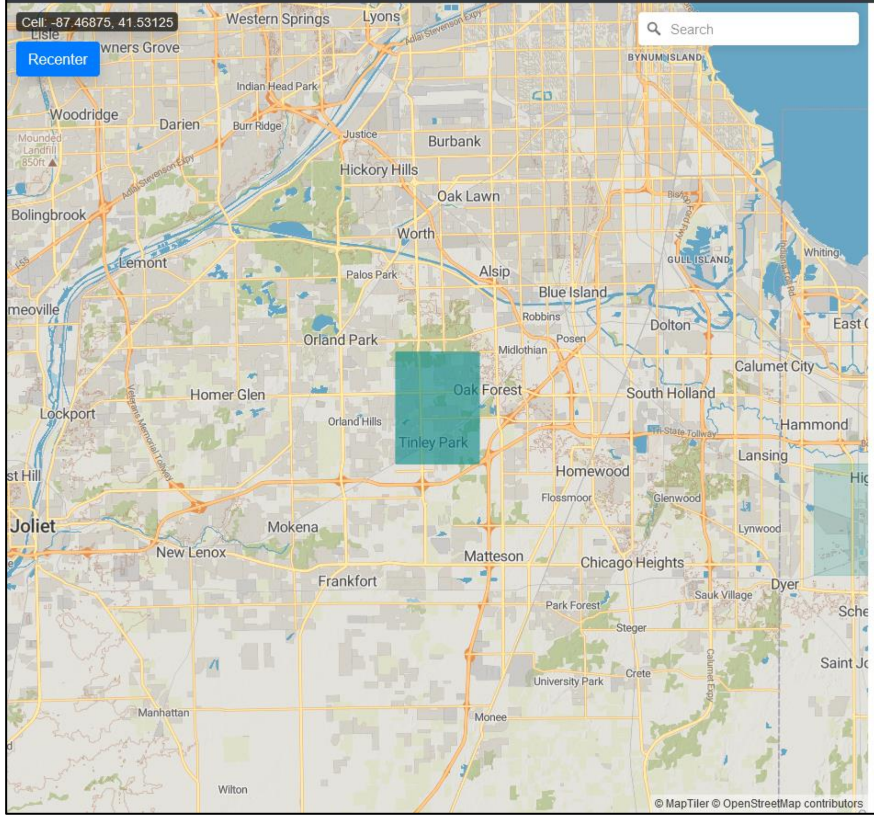
DURATION	AVERAGE RECURRENCE INTERVAL						
	1 year	2 years	5 years	10 years	25 years	50 years	100 years
60-min	1.33	1.53	1.81	2.19	2.60	3.02	3.42
2-hr	1.54	1.79	2.14	2.61	3.12	3.65	4.15
3-hr	1.66	1.92	2.32	2.84	3.41	4.01	4.57
6-hr	1.98	2.29	2.78	3.47	4.27	5.13	5.98
12-hr	2.29	2.64	3.18	3.94	4.82	5.76	6.69
24-hr	2.69	3.26	4.17	4.95	6.17	7.26	8.49
2-day	3.10	3.75	4.73	5.58	6.89	8.04	9.35
3-day	3.30	3.97	4.96	5.84	7.20	8.40	9.80
4-day	3.50	4.19	5.20	6.10	7.51	8.75	10.24
7-day	4.06	4.83	5.88	6.84	8.29	9.57	11.09
10-day	4.58	5.43	6.55	7.59	9.10	10.46	12.03

Source: https://precipitationfrequency.ncics.org/

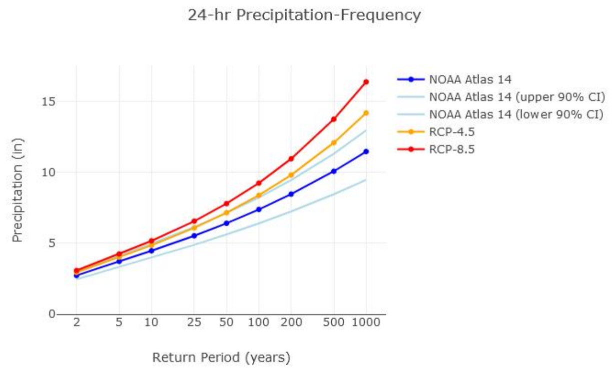
Climate Model Tools

Future Climate Precipitation-Frequency Tool

wsp ClimateEVA



Future Climate Precipitation-Frequency



	Atlas-14 24-hr Precipitation-Frequency			Future:Baseline		Future Climate	
T (yrs)	Depth (in)	Upper 90% CI (in)	Lower 90% CI (in)	RCP-4.5	RCP-8.5	RCP-4.5 (in)	RCP-8.5 (in)
2	2.732	3.057	2.456	1.079	1.127	2.949	3.080
5	3.728	4.165	3.341	1.081	1.140	4.028	4.250
10	4.474	4.984	3.99	1.087	1.157	4.862	5.175
25	5.533	6.157	4.89	1.101	1.187	6.089	6.567
50	6.418	7.143	5.626	1.116	1.216	7.160	7.805
100	7.392	8.236	6.411	1.135	1.252	8.390	9.254
200	8.474	9.462	7.25	1.159	1.295	9.825	10.972
500	10.09	11.335	8.469	1.200	1.364	12.106	13.766
1000	11.482	12.973	9.477	1.237	1.428	14.207	16.400

www.wsp.com/en-us/hubs/future-ready

Solutions & Resilience

Solutions – Bridges and Culverts

- Is the data to determine flows and overtopping elevation outdated?
- Should the structure be elevated?
- Is the road an evacuation route?
- Does this road provide access to a critical facility?
- What do future conditions look like based on the design life?

Solutions – Levees, Flood Walls, and Berms

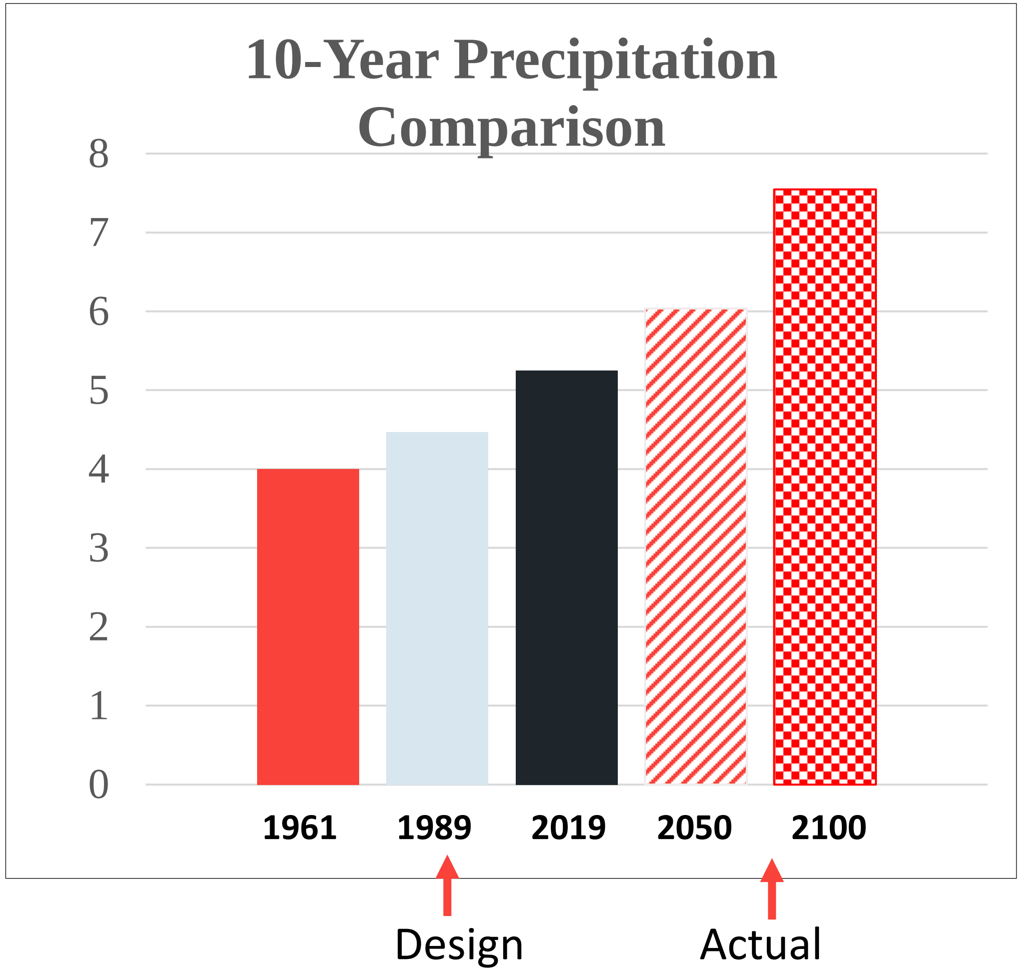
- Is the data to determine flows and overtopping elevation outdated?
- What benefit would be achieved if the structure is raised? Is it cost-effective?
- Does the structure protect a critical facility?
- What do future conditions look like based on the design life?

Solutions - Sewers

- Storm sewers are designed using the 10-year rainfall value
- Design life is 75 years
- Because of the lag in updating design values, sewers may be undersized to convey today's rainfall

Solutions – Sewers (cont.)

- If a sewer is designed and built in 2018, the 1989 data would be used because that's the most recent data available.
- Yet, when the data is updated the following year, the sewer is expected to handle those increased flows.
- Based on the design life, the sewer is expected to last until 2093 and convey 2050 flows.



Solutions – Sewers (cont.)

Trunk sewer lacking future capacity

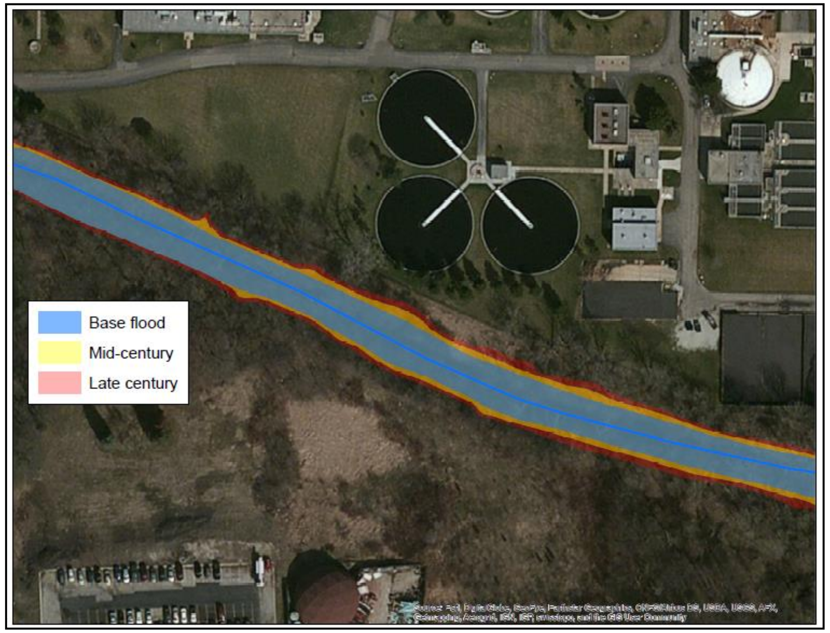
- Run the design computations with the future condition precipitation to evaluate which pipe segments will lack capacity in the future.
- To minimize costs, only pipe segments lacking capacity should be upsized or increased slope.

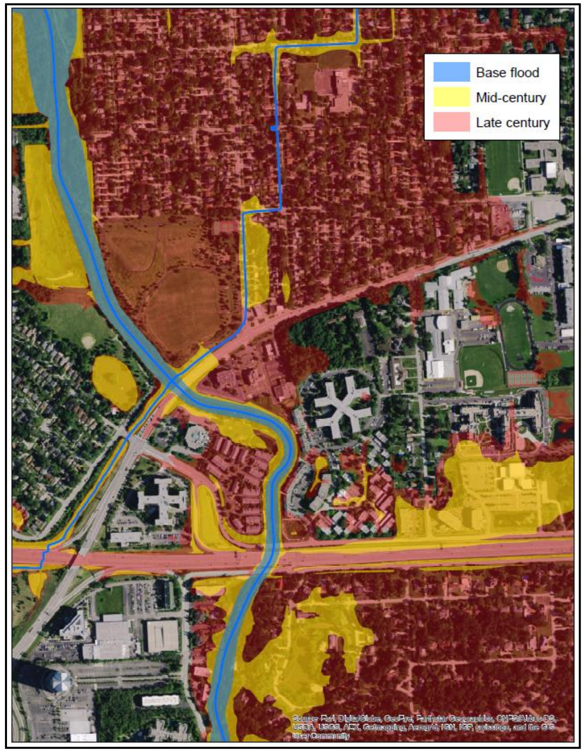
Solutions – Stormwater Detention Basins

- Designed for the 100-year, 24-hour storm event
- Design life is 25+ years
- Typically surrounded by buildings and roads with little opportunity for expansion
- Undersized when the design storm increases
- For existing basins, retrofit the overflow weir to handle future flows
- For proposed basins, size the overflow weir to handle future flows

Solutions – Floodplain Mapping

Future floodplain maps can be created using future precipitation values utilized in existing hydrologic and hydraulic models.





Uses:

- Set-backs of critical buildings
- Hazard mitigation needs
- Infrastructure vulnerability study

Resilience

- Analyze the feasibility of retrofitting
  - Quantify the costs of retrofitting
  - Elevating or floodproofing a building later can be cost prohibitive
  - Will elevation constraints allow for retrofits?
- Analyze the cost of temporary loss of use (critical facility)
- Quantify the costs of repair or rebuilding
- Quantify the costs to build to withstand future conditions now
  - Upsizing sewer pipes is a small percentage of the overall project cost
  - Increasing sewer slope costs little to nothing

Resilience

- Limit property and infrastructure damages
- Limit economic losses
- Avoid loss of essential services (utilities)
- Avoid loss of function of critical facilities and roads
  - Displacements, disruptions
  - Road closures, detours
- Reduce costs to repair or rebuild from more frequent and/or extreme events
- Responsible spending of taxpayer money
- Maintain credit rating for bonds

Regulatory Requirements

Regulatory Requirements

Federal Flood Risk Management Standard (FFRMS)

- Reinstated on May 20, 2021, in Executive Order 14030 Climate-Related Financial Risk
- Climate-Informed Science Approach

Hazard Mitigation Plans (Local and State Guides)

- Climate change increases the frequency, duration and intensity of natural hazards
- Address climate change in its risk assessment and includes adaptation actions in its mitigation strategy to reduce risk to current and future events

Source: www.fema.gov/sites/default/files/documents/fema_local-mitigation-planning-policy-guide_042022.pdf

Regulatory Requirements

Bipartisan Infrastructure Law – Promoting Resilient Operations for Transformative, Efficient, and Cost-Savings Transportation (PROTECT) Formula Program

- Planning grants to enable communities to assess vulnerabilities to current and future weather events… and changing conditions… on transportation systems
- Plan improvements and response strategies to address vulnerabilities
- Climate Change and Sustainability
- Resilience Improvement Plans
  - Reduce greenhouse gas emissions; use nature-based solutions and sustainable materials
- References:
  - FFRMS: redefining base flood to account for future climate conditions
  - CMIP tool
  - SERDP Intensity-Duration-Frequency Curve tool

Source:
www.fhwa.dot.gov/environment/sustainability/resilience/policy_and_guidance/protect_formula.pdf

Regulatory

Illinois National Pollutant Discharge Elimination System (NPDES) Permit No. ILR40

5. Post-Construction Storm Water Management in New Development and Redevelopment

b. Strategies shall be amenable to modification due to climate change. https://www.epa.gov/climate-change-water-sector

e. ii. C. Evaluation of existing flood control techniques to determine potential impacts and effects due to climate change

k. Water quality impacts… due to climate change

Source: https://external.epa.illinois.gov/WebSiteApi/api/PublicNotices/GetDocument/15677

Summary

- Climate model data is available to use for designing infrastructure to withstand future conditions
- Federal and state programs are endorsing climate resiliency be addressed in infrastructure design
- Local governments could provide guidance to use of future precipitation values for design in technical guidance so that they are applied consistently

Q & A

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