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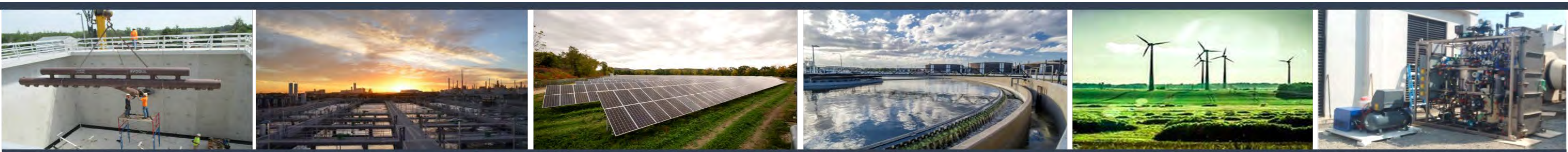
We will begin our presentation in a few minutes…



Leadership and Excellence in Environmental Engineering and Science

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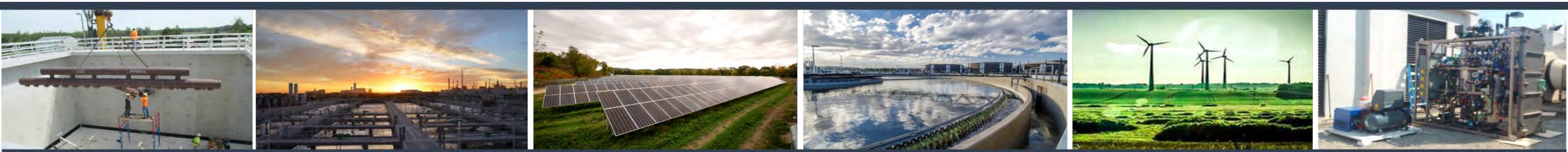


Leadership and Excellence in Environmental Engineering and Science

The New Era of Climate Change: Turn Risk into Opportunity

Paul S. Chinowsky, PhD and Jake Helman

Director and Lead Technical Engineer, Resilient Analytics

Outline

- Introductions
- Why is Climate a Concern?
- Understanding Climate Limitations
- 4 Levels of Engineering Opportunities
- Where to Start

Who is Resilient Analytics?

RESILIENT ANALYTICS

2006

Research and consulting in financial climate impact analysis since 2006

- Data driven decision support for resilient infrastructure
- Based engineering design
- Adapt versus react financial impact
- Full spectrum of assets

2016

RA incorporated

- International (WB, UN), National (EPA), Local (Counties and Cities), and Private Clients
- 30 peer-reviewed publications
- Multiple peer-reviewed committees

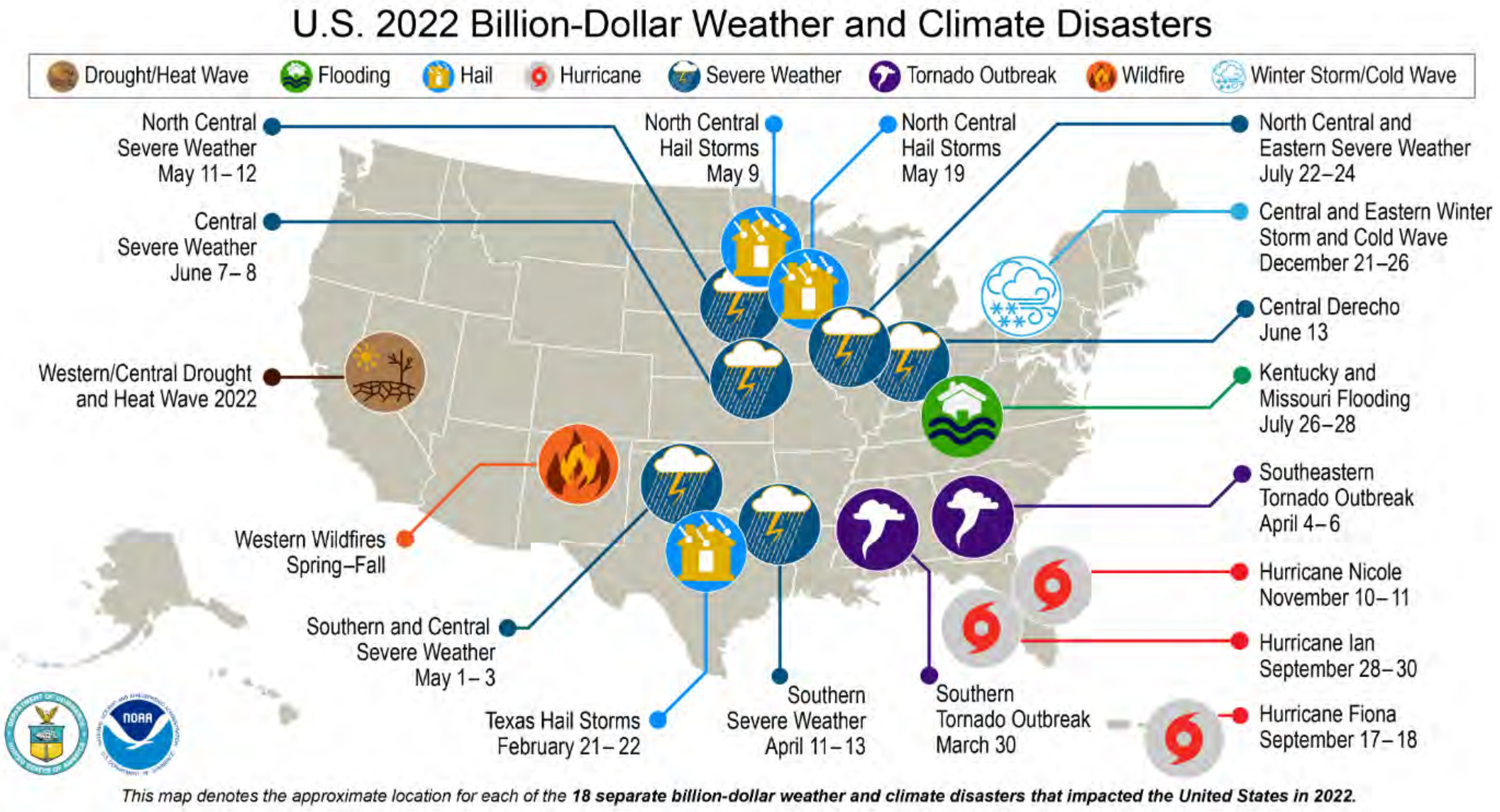
2022

Stanley Consultants acquisition

Stanley Consultants INC.

www.resilient-analytics.com

Climate Impacts are Happening Now



NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

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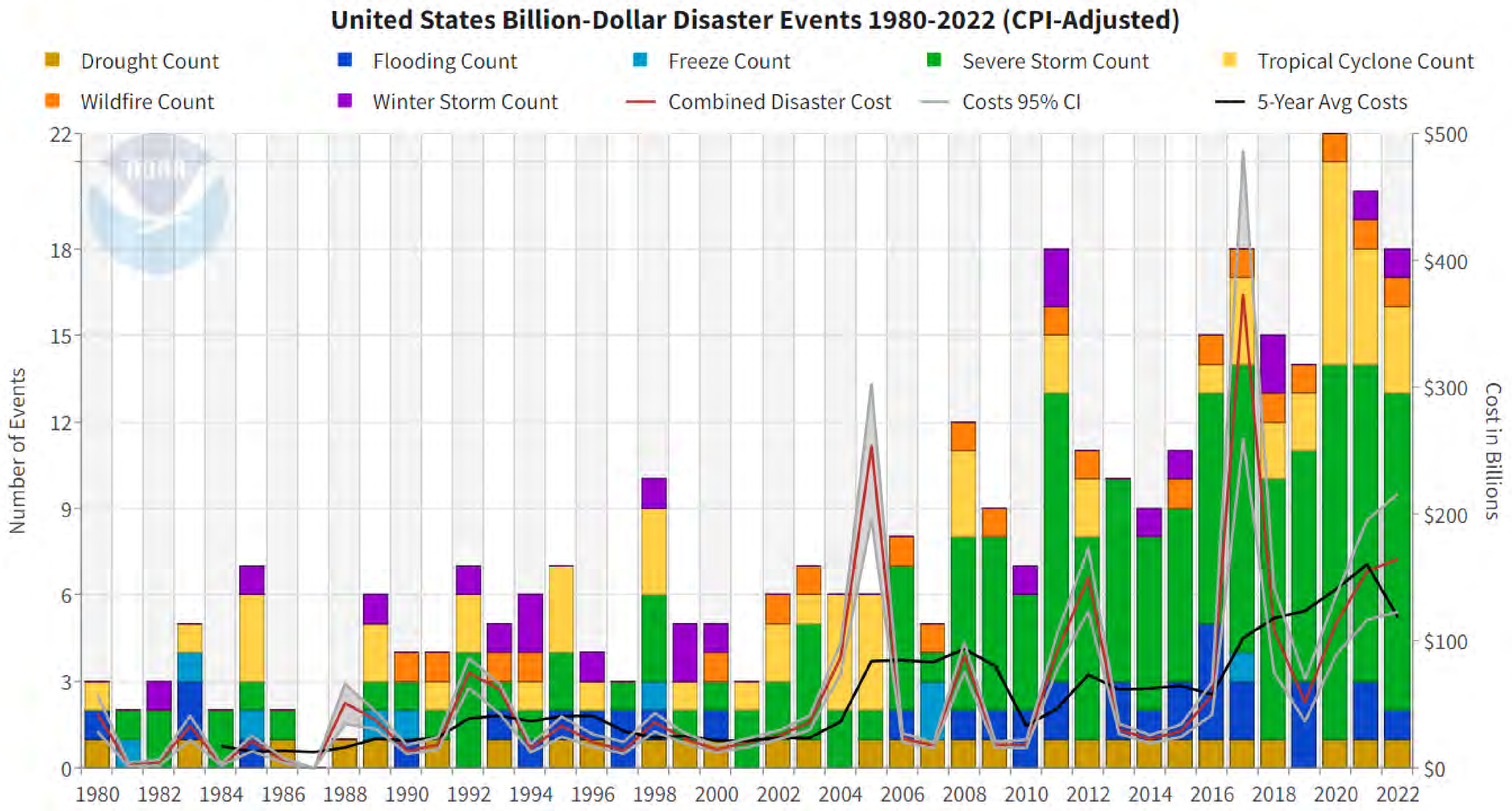
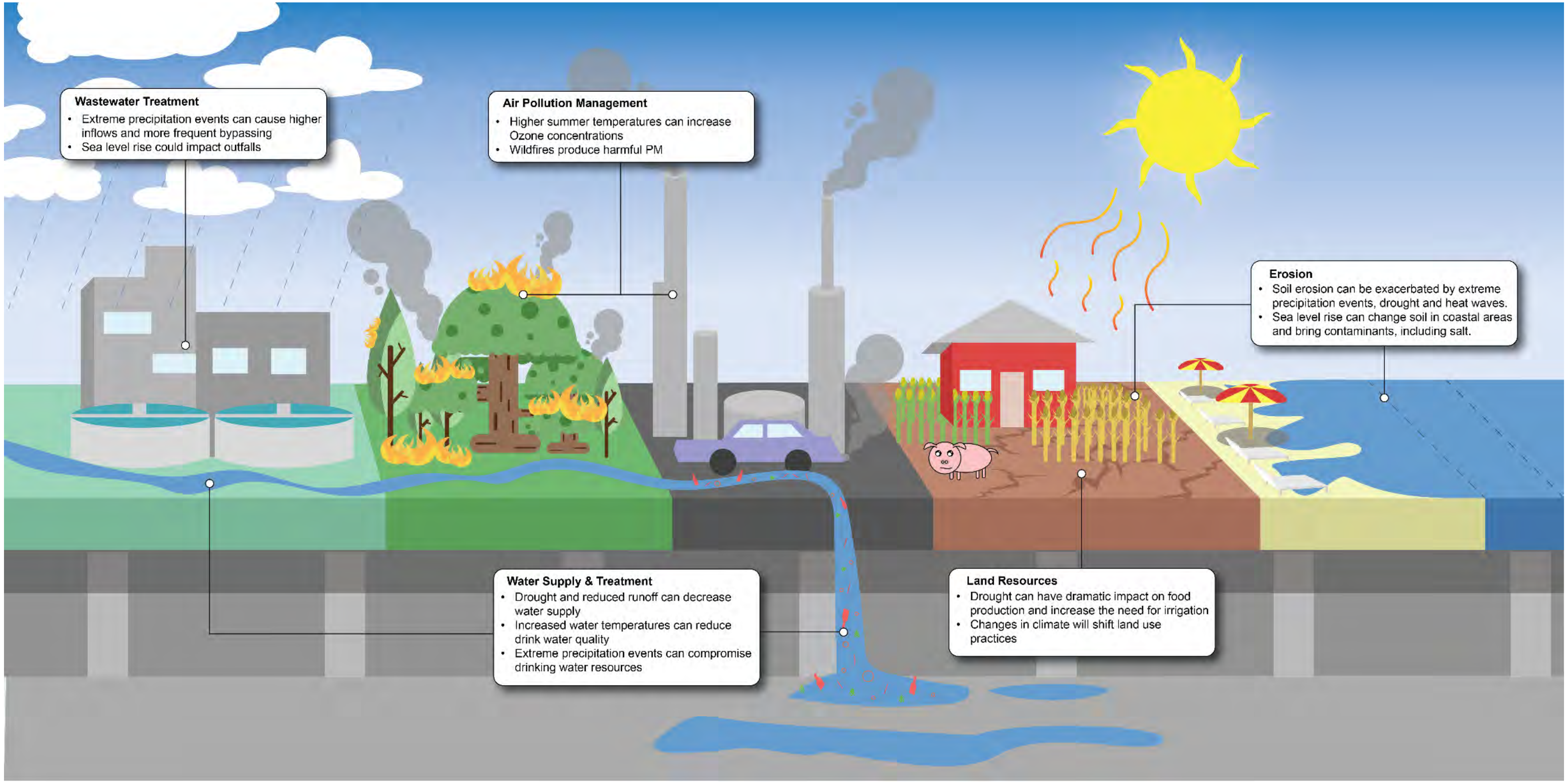


NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

Climate Impact on Engineering

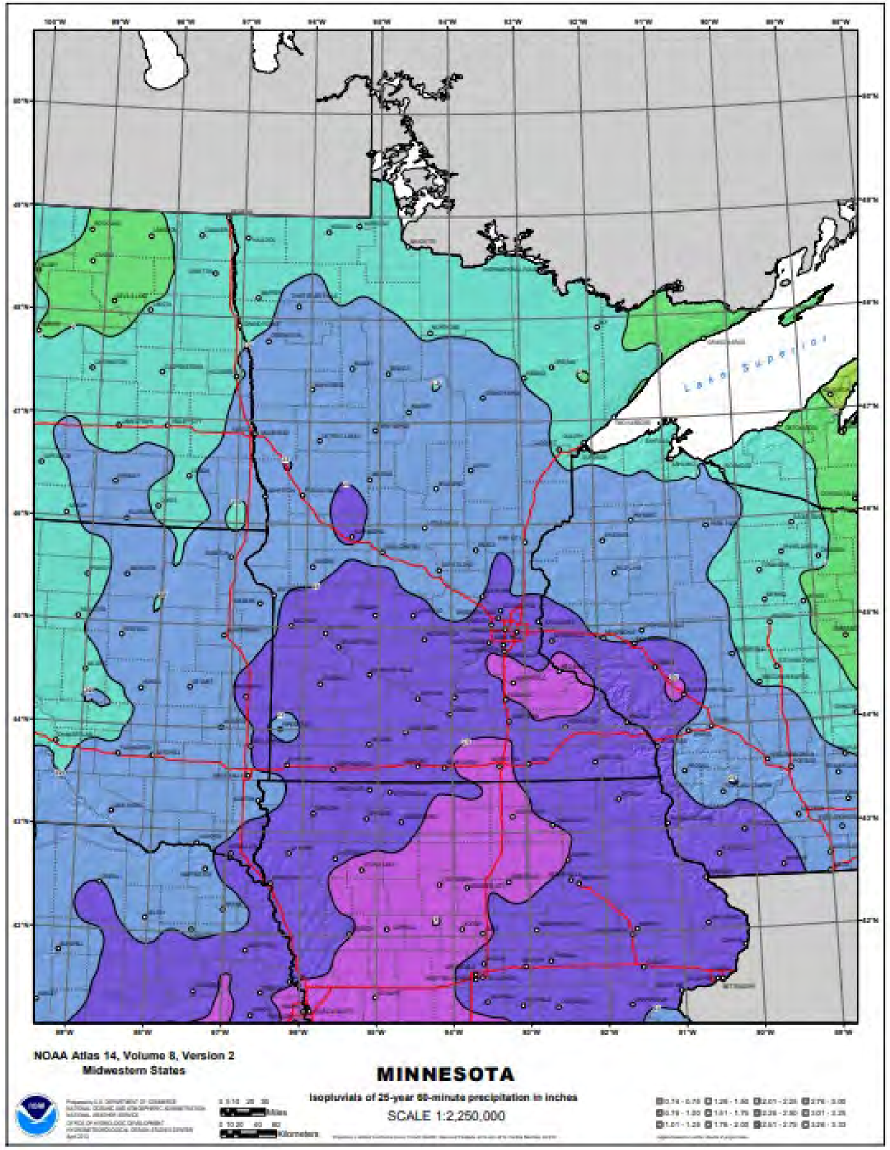


Market Drivers and Opportunity

- Climate change is no longer an abstract concept, but rather a concern that is appearing in RFPs, developer discussions and investment decisions.
- Engineers need to be prepared for this and it needs to be done correctly.
- Many engineering firms choose to avoid climate change risks until they become the new standard. However, there is an opportunity to become a trusted partner with owners who understand climate risks and are ready to implement this new risk metric.

Climate in Engineering Design

- Climate has always been a factor in engineering design
  - Wastewater treatment inflow
    - 5- and 25-year 60-minute precipitation
  - Retention pond
    - System should be designed for the maximum wet year and minimum evapotranspiration year of record
- Why are we designing the infrastructure of the future to past climate conditions?
  - Historically that is the only data we had to go off
- Climate modeling changes that narrative
- We now have the capability to design the infrastructure of the future to projected climate conditions



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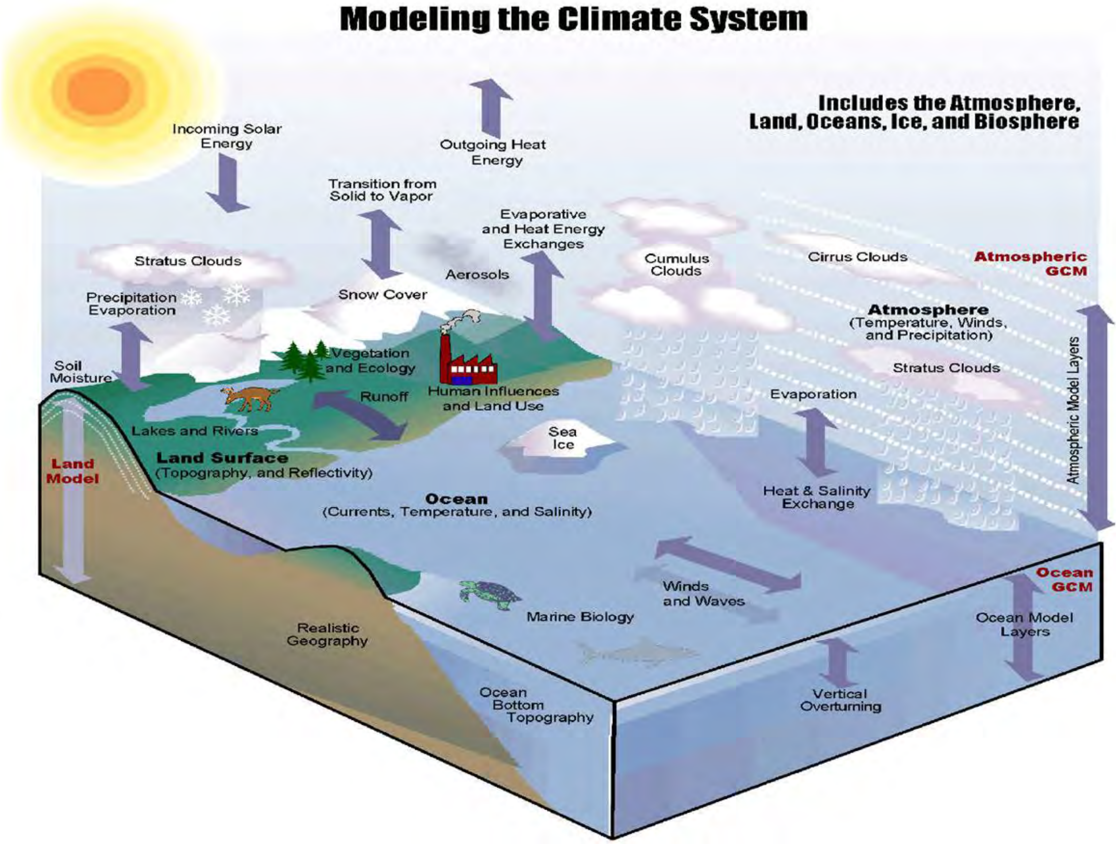
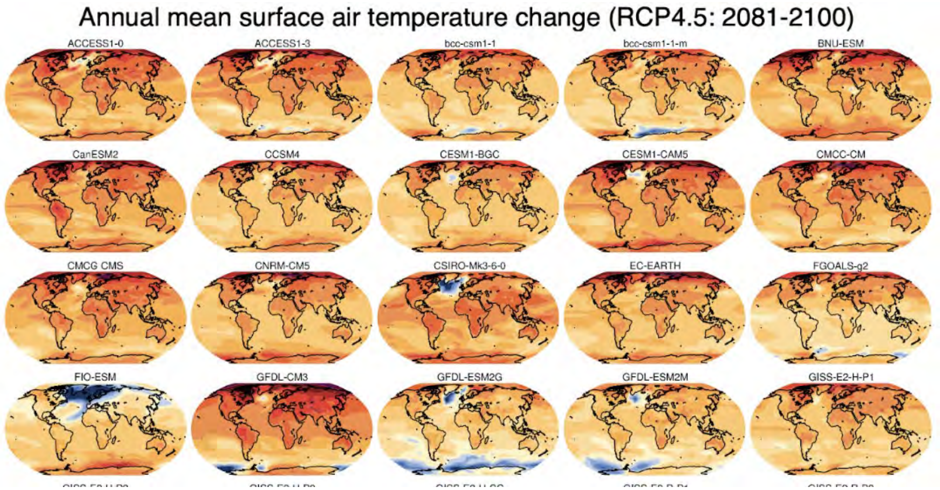
Climate Projection Overview

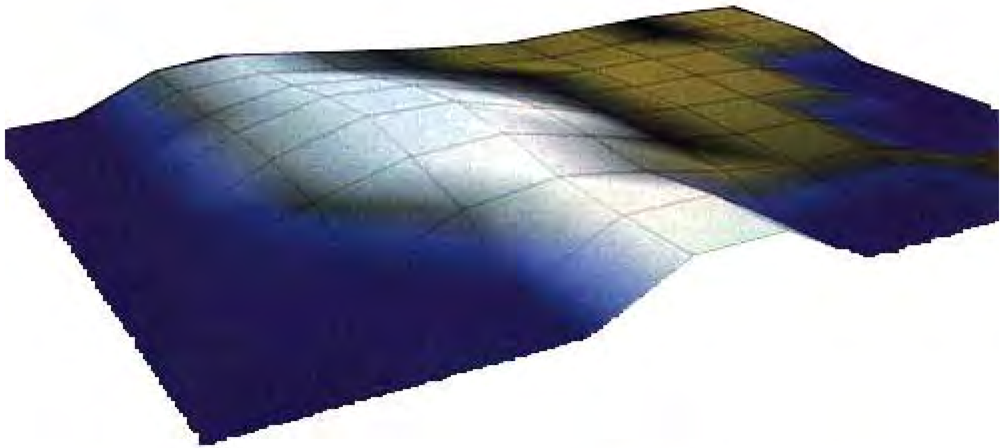
- There are many models of climate change and many emissions scenarios
- Each model is deterministic and has an individual approach to modeling all the different subsystems that make up the overall climate system
- This leads to variances in projections
- There is no single answer to the future environment

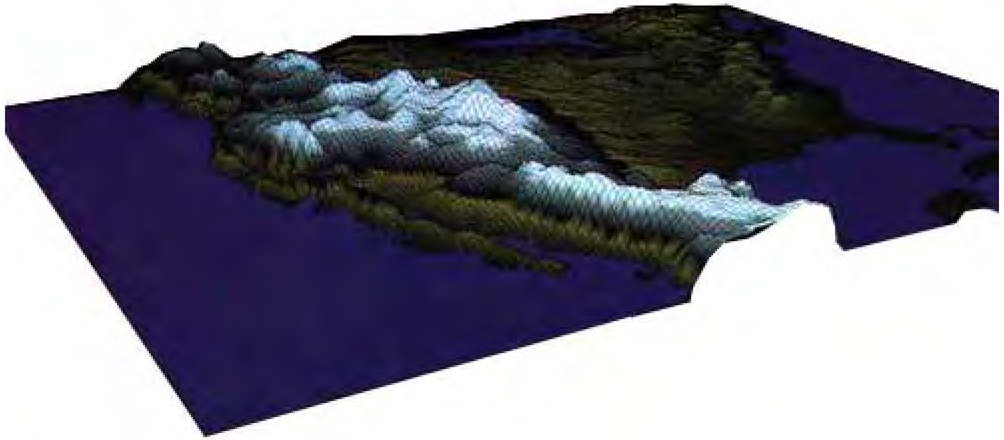




Climate Projection Overview

- Models are downscaled to provide more detailed projections
- The higher the resolution, the greater specificity for a project
- Not all models are available at a higher granularity
- Potential for unrealistic accuracy – be careful as an engineer!





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Climate - Hazards

Augment base variables from datasets, with additional data required for client analysis.

Base Variables
Humidity
Precipitation
Wind
Temperature
Solar Irradiance

→

Derived Variables
Wildfire (KBDI)
Drought (SPEI)
Heat Index/Heat Wave
Cooling/Energy Demand (CDD)
Flood Events
Sea Level Rise/Storm Surge
Other

→

Climate Variable Dataset

Example of additional variable development to augment base climate variables:

Determination of Extreme Heat Day (EHD) temperature threshold:

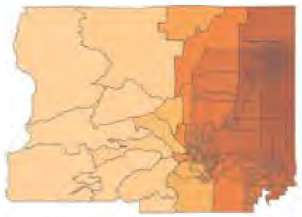
$$days\ in\ baseline\ period = 365 \times 20 = 7{,}300\ days$$

$$hottest\ 2\%\ of\ days = 7{,}300 \times 2\% = 146\ hottest\ days$$

Threshold = average of 146 hottest days

Any additional days above this threshold indicate an increase in extreme heat days.

Where Do Climate Models Fit in Engineering?

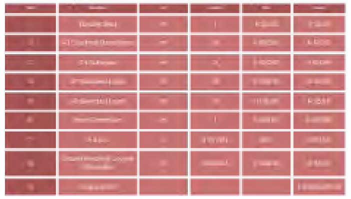


Level 1: Awareness

What are the future climate conditions projected to be in specific geographic areas?

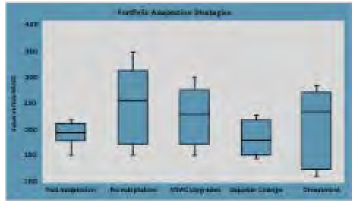
Level 2: Vulnerability

What specific assets are vulnerable to projected climate change impacts?



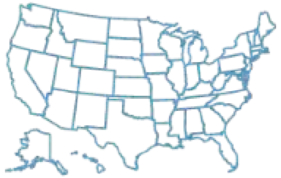
Level 3: Operational

What are the financial, social, and operational costs of climate change to assets in geographic areas of concern?



Level 4: Strategic

What are the financially appropriate actions that should be taken in the near- and long-term to mitigate climate change impacts including adaptations and prioritization?



- Global
- National
- Regional
- Asset

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Application of Climate Projections to Engineering

- Design Risk
- Acute Risk
- Operational Risk
- Adaptation

Case Study

Water utilities across the country will experience new and enhanced vulnerabilities due to future increases in **extreme heat events**. The Water Utility Climate Alliance (WUCA) and the Association of Metropolitan Water Agencies (AMWA) recognized these threats and sponsored a study to analyze the impact of such extreme temperature events on critical water utility physical infrastructure assets and personnel.

Operational Areas of Impact

Personnel: health, safety, and productivity

Electrical Equipment: degradation of lifespan

Cooling Costs: cooling equipment energy usage

Facilities: roof and parking lot degradation

Personnel

The projected heat index in many regions will place workers at high levels of risk if no adaptation measures are taken.

The number of hours where breaks will be required will increase significantly, resulting in costs that could reach six figures for many water utilities by 2030.

If no adaptation procedures are put in place, it is projected that workplace accidents could increase 8% by 2030 and 17% in some locations by 2070.

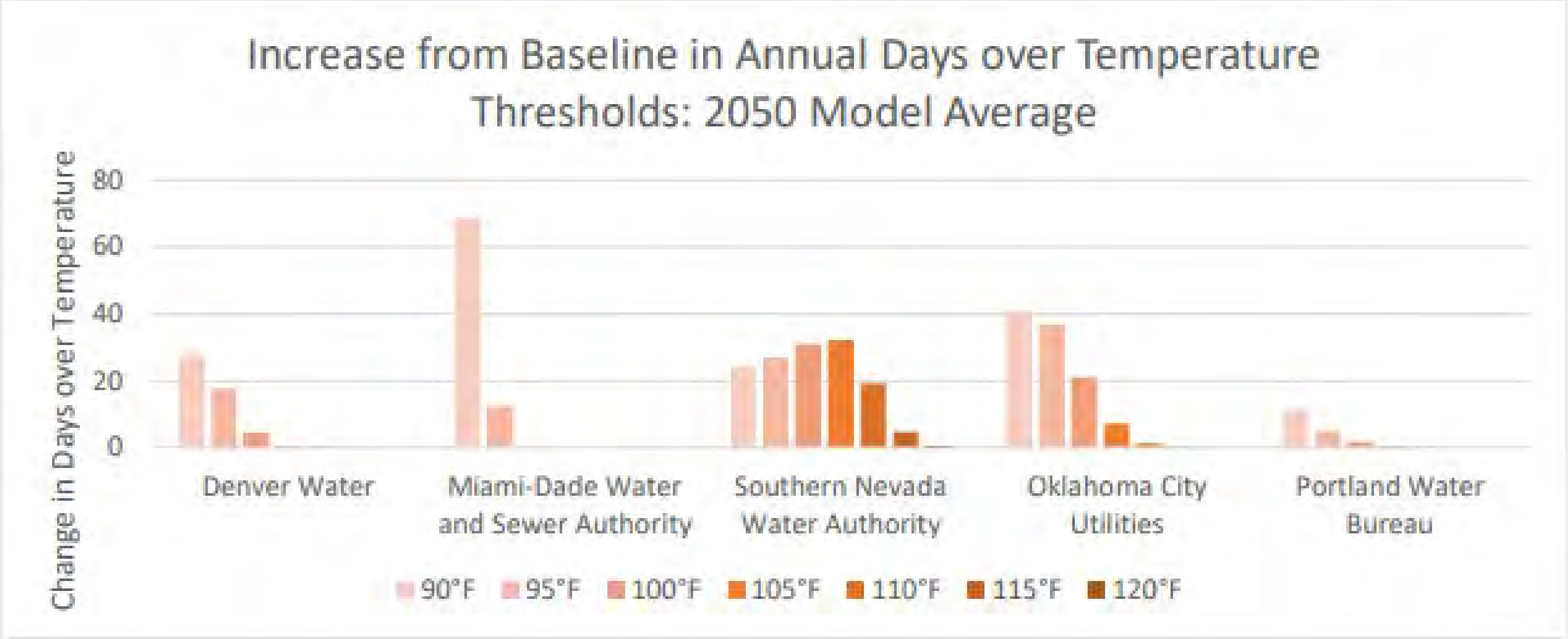


Figure 3: Increase from baseline in Annual Days Over Temperature Thresholds in 2050. *Values shown represent the average values across all climate models and RCPs. More extreme values are projected by individual models.*

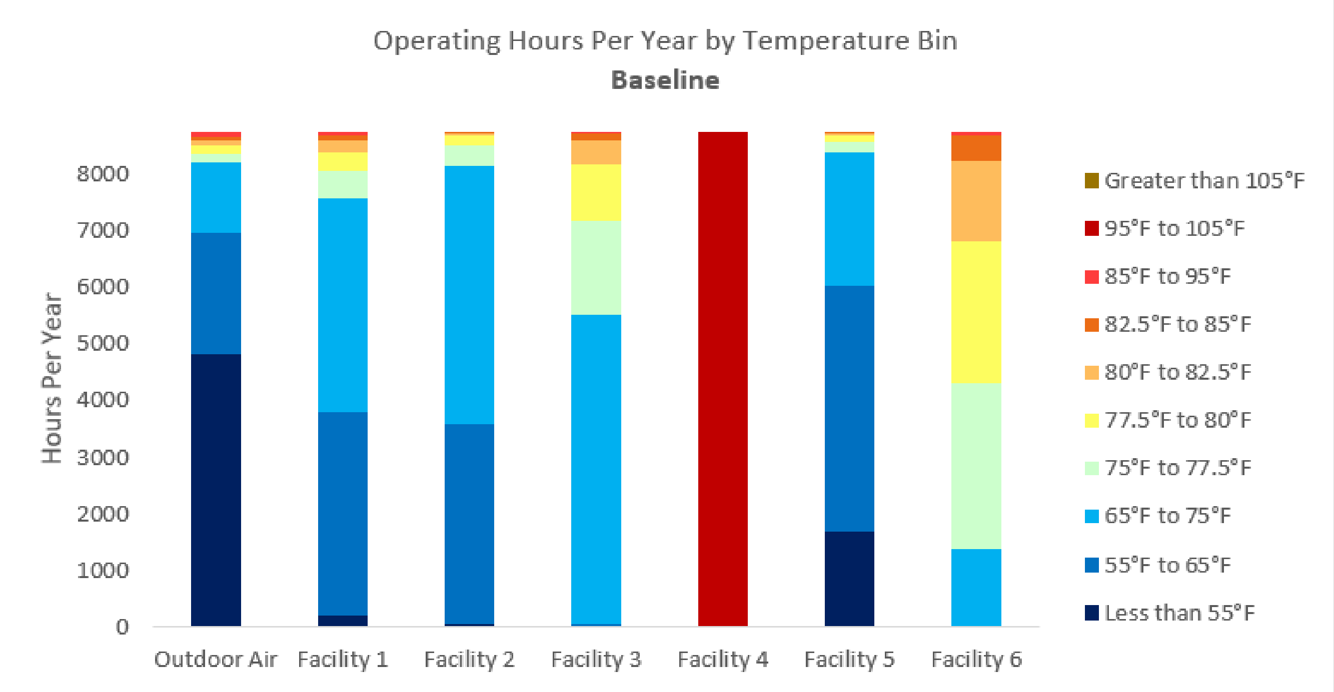
		2030	2050	2070
Moderate Standard	**RCP 4.5**	$14,826	$31,423	$43,028
	RCP 8.5	$14,468	$39,383	$64,868
Strict Standard	**RCP 4.5**	$64,853	$141,255	$196,023
	RCP 8.5	$66,012	$182,839	$310,517

Case Study: Annual costs above baseline from lost productivity

Electrical Equipment

The **ambient operating temperature** within which electrical equipment operates is a key factor in its lifespan. As ambient temperature increases the expected **lifespan of the equipment decreases**, and vice versa.

Motors, motor control centers (MCCs) and variable frequency drives (VFDs) were the primary focus of this study because of the critical role they play in water utility operation.



Case Study: *Ambient space temperature profile for each facility illustrated by the number of hours per year that each facility's ambient space temperature falls within the temperature bins shown. Outdoor air temperature given for reference. Total hours = 8,760 for each facility.*

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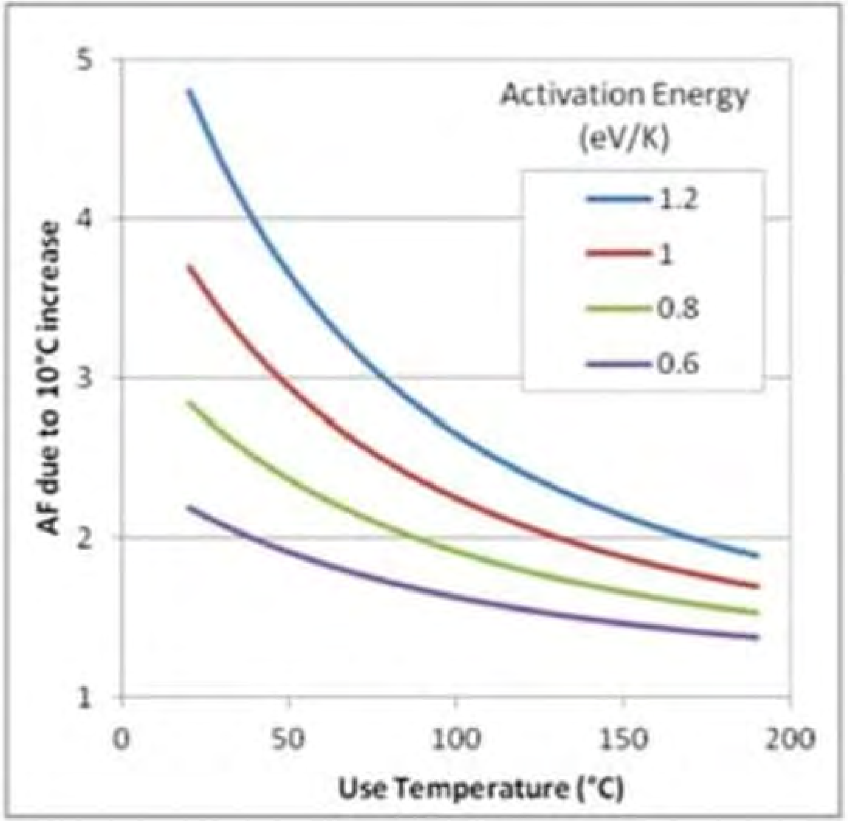

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		Change from Baseline Cost of Motor Replacements Over 20 Years *Per Facility*					
		Facility 1	Facility 2	Facility 3	Facility 4	Facility 5	Facility 6
12 Hour	2030 RCP-4.5	$107,039	$41,556	$33,077	$1,120	$2*	$2,161
	2030 RCP-8.5	$126,171	$50,009	$39,377	$1,338	$2*	$2,687
	2050 RCP-4.5	$177,937	$71,957	$55,119	$1,863	$3*	$4,036
	2050 RCP-8.5	$224,951	$91,252	$68,995	$2,319	$4*	$5,179
	2070 RCP-4.5	$225,440	$91,649	$69,356	$2,334	$4*	$5,214
	2070 RCP-8.5	$342,351	$140,425	$104,419	$3,489	$5*	$8,108
24 Hour	2030 RCP-4.5	$214,078	$83,112	$66,155	$2,239	$3*	$4,322
	2030 RCP-8.5	$252,343	$100,018	$78,754	$2,676	$4*	$5,374
	2050 RCP-4.5	$355,875	$143,914	$110,239	$3,725	$6*	$8,072
	2050 RCP-8.5	$449,902	$182,503	$137,991	$4,639	$7*	$10,359
	2070 RCP-4.5	$450,879	$183,297	$138,712	$4,668	$7*	$10,429
	2070 RCP-8.5	$684,703	$280,851	$208,837	$6,977	$11*	$16,216

Case Study: *Change compared to baseline in the estimated cost of additional motor replacements over the 20-year analysis periods 2030 (2021-2040), 2050 (2041-2060) and 2070 (2061-2080). Values are reported* ***per facility****. *Values represent incremental cost per horsepower.*

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Cooling Demand and Facilities

Cooling costs are projected to increase by 4% to 5% by 2030, 9% to 13% by 2050 and 12% to 23% by 2070.

From 2021 to 2080, we estimate the average increase in cooling cost for the facilities included in this study to be between $2.6 million and $4.1 million.

Shorter lifespans for roofing systems and parking lot surfaces

We recommend these additional costs be considered in near- and long-term budget planning.

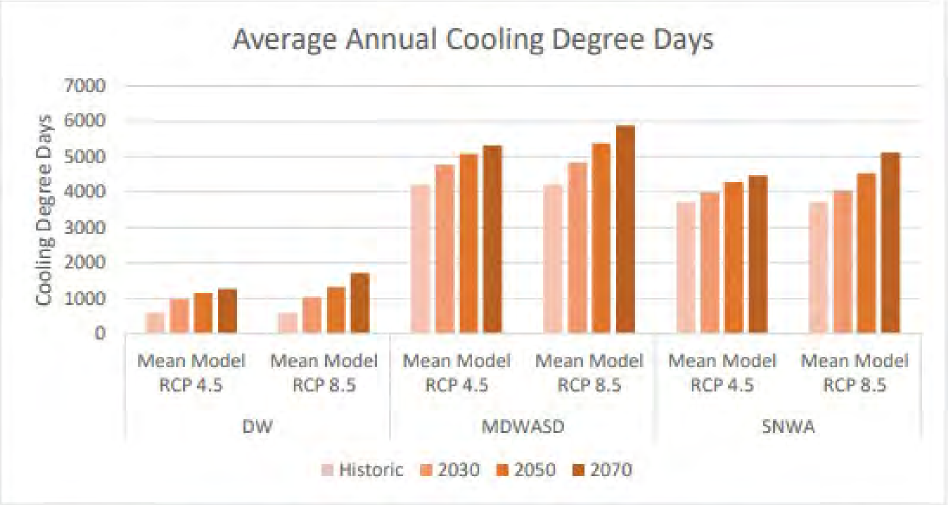


Figure 5 Increases in Average Annual Cooling Degree Days at the three utilities that included conditioned facilities in the scope and opted to analyze the impact of rising temperatures on their cooling demand.

		2030		2050		2070	
	Historic	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
AMS	8.2	7.9	7.9	7.6	7.4	7.5	6.9
RMWTF	8.6	8.3	8.2	8.0	7.7	7.8	7.2
LVVWD	30.3	28.0	27.7	26.1	24.7	25.0	21.8
All Facilities	9.3	9.0	8.9	8.6	8.4	8.4	7.8

Table 7: Payback period in years for installing high efficiency chillers

Adaptation

Personnel: Worker scheduling, adopting new rest cycle standard, confined spaces

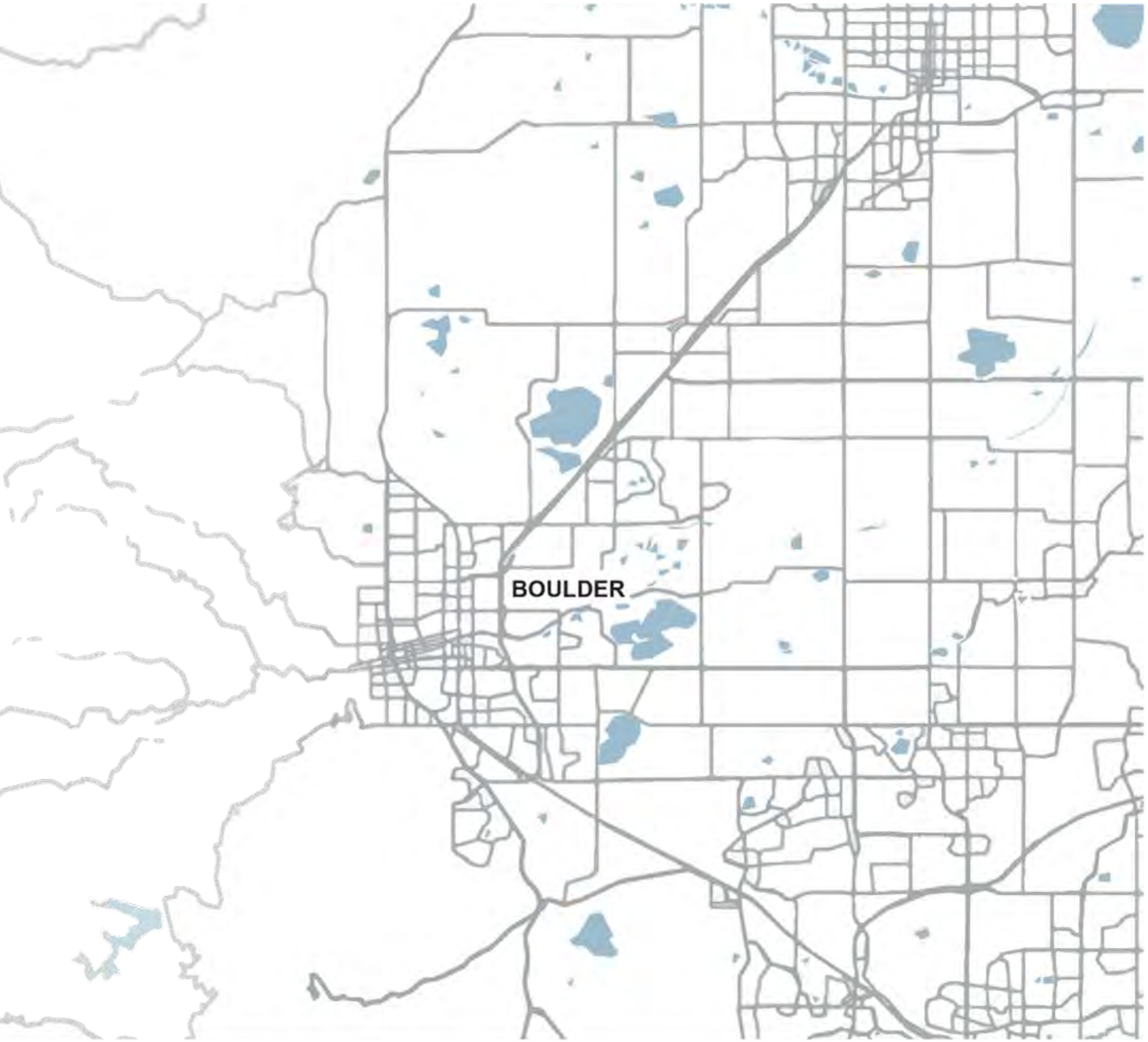
Electrical Equipment: Higher insulation temperature ratings, enhance maintenance schedules, have replacements on hand

Cooling Costs: Commissioning, envelope improvements, air-side economizer

Facilities: Cool roof coating, upgrade binder design temperature

BOULDER, COLORADO

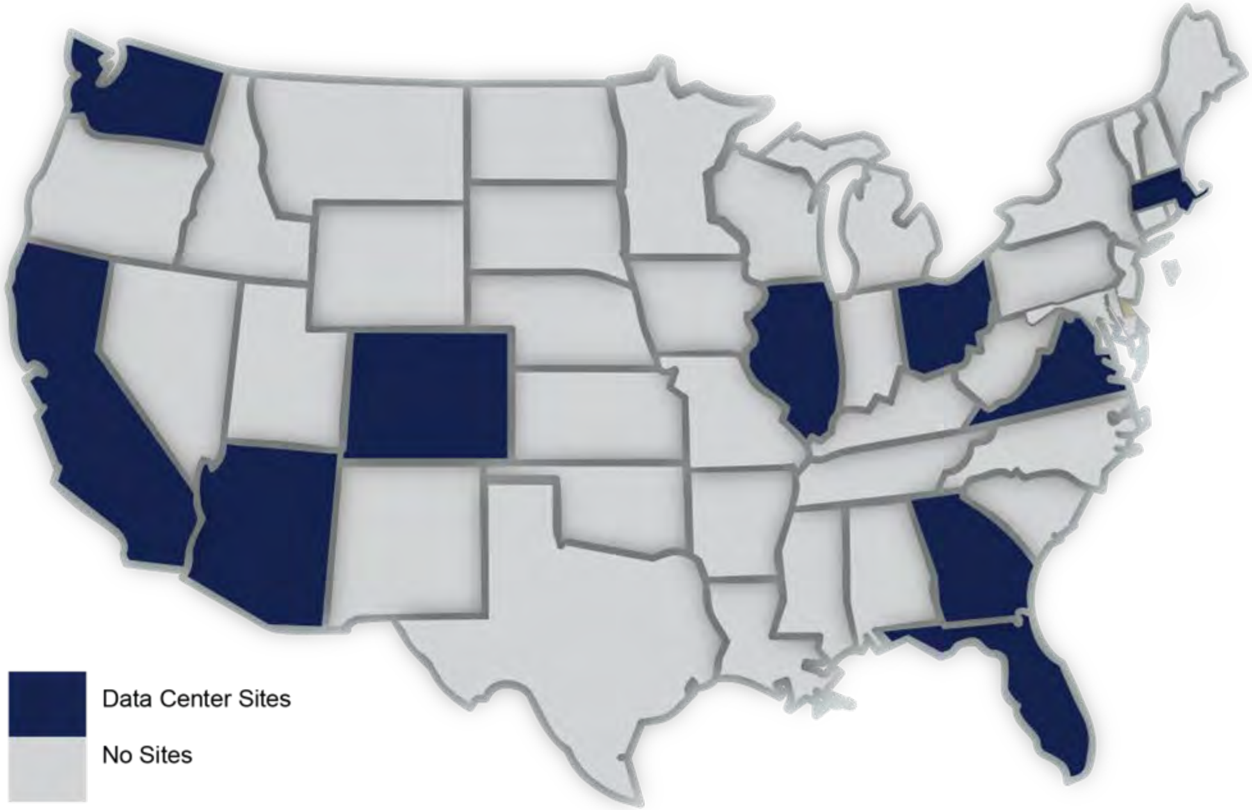
Cost impacts from 2020 to 2050



- Wildfire area is projected to increase by 38%
- Severity and length of droughts to increase
- $4.6 million in cooling center operating costs
- $16 million in investments to increase system capacity
- Road maintenance to double to $1,130 per mile per year
- $68 million for structural improvements to bridges
- $19 million in adaptation costs for precipitation impact
- Increase in cooling costs of 54% to 75%

DATA CENTER RISK ANALYSIS

The data center risk analysis quantifies how climate change is projected to impact data centers across the US, with a specific focus on a facility in Santa Clara, CA. The analysis is broken up into three different categories: **design risk, operational risk, and acute risk**.
Design Risk: Represents the vulnerability of changes to building design standards, including HVAC.
Operational risk: Represents the vulnerability to changes in cooling energy and the amount of free cooling hours available at a location.
Acute risk: Represents the physical risks (flooding, wildfire, etc.) to the data center site and surrounding infrastructure.



Key Findings For All 10 Sites:

Design Risks

- Extreme annual temperature is projected to increase for all locations by 0.9°F to 3.1°F by 2030 and 1.6°F to 5.1°F by 2050.
- 0.4% humidity ratio (grains of moisture/lb dry air) is projected to increase for all locations to 9.0% by 2050.

Operational Risks

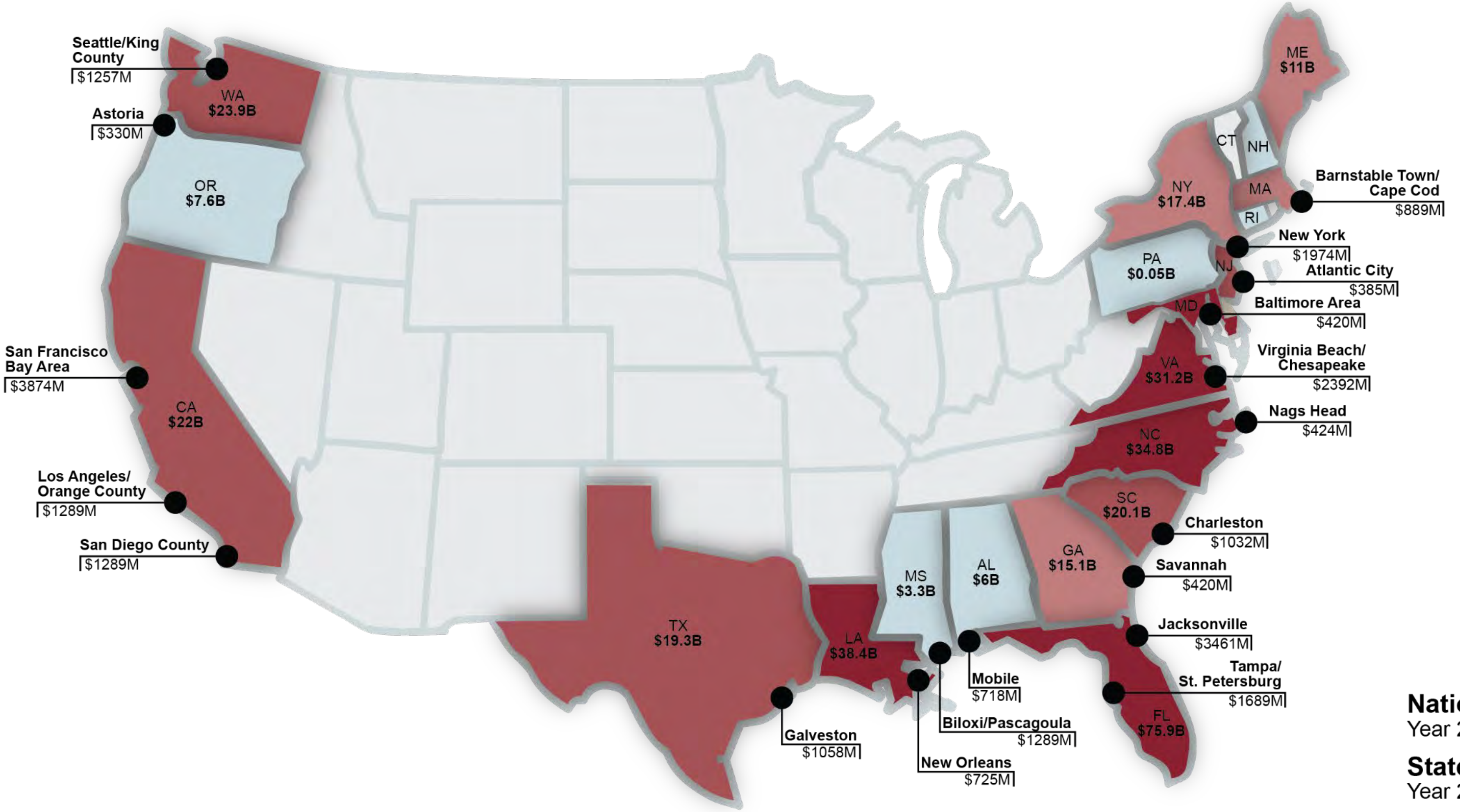
- Cooling costs are projected to increase by 6% to 11% by 2030 and 13% to 24% by 2050.
- Total cooling costs are projected to increase by $3.5 to $6.6 million between 2020 to 2040.

Acute Risks

- 70% of locations are projected experience an increase in extreme precipitation events by 2030.
- 30% of locations are projected to experience 20 additional days of extreme wildfire risk days annually by 2030.

NATIONAL SLR IMPACTS

State and city costs by 2040



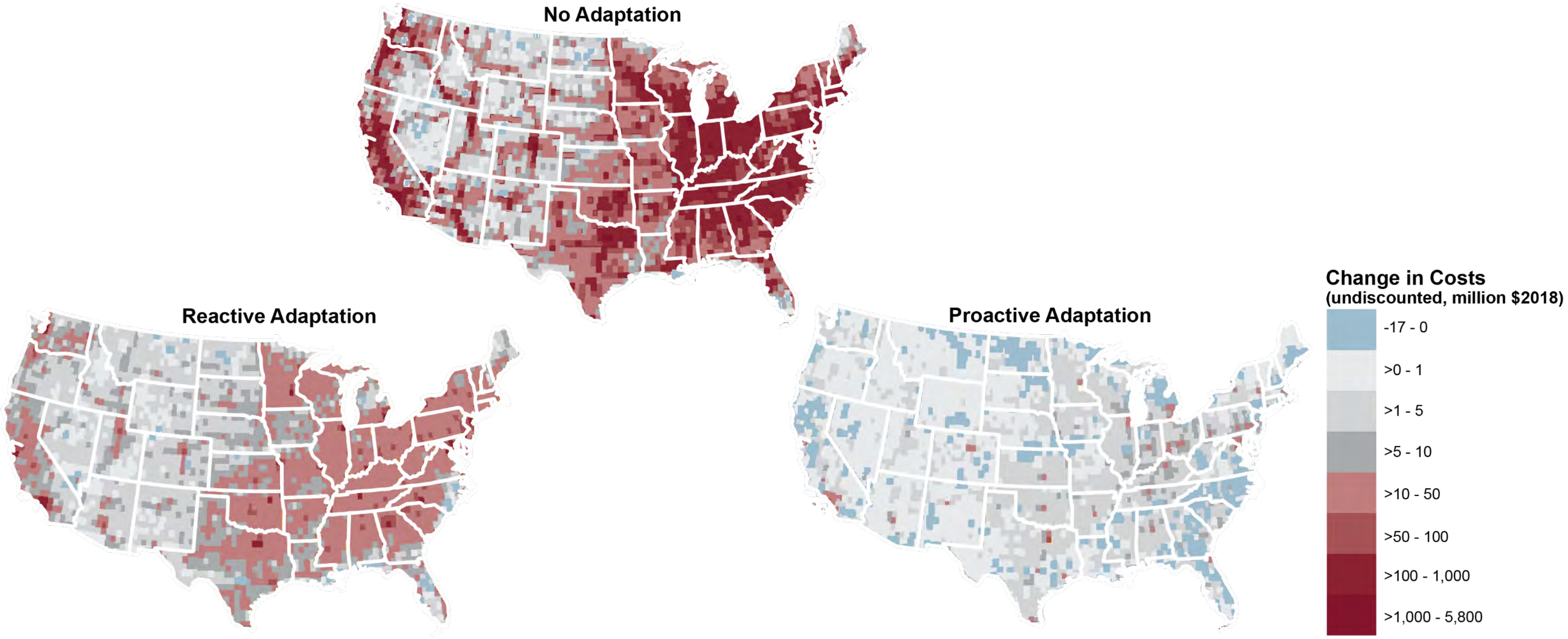
MD	$27.4B
NJ	$25B
MA	$18.7B
DE	$9.4B
RI	$2.9B
NH	$1B

National costs due to sea level rise
Year 2040: $416B | Year 2100: $518B

State protection miles 15% increase in 60 years
Year 2040: 50,147 miles | Year 2100: 60,219 miles

EPA NATIONAL CLIMATE IMPACTS STUDY

Risk factors for highways and bridges



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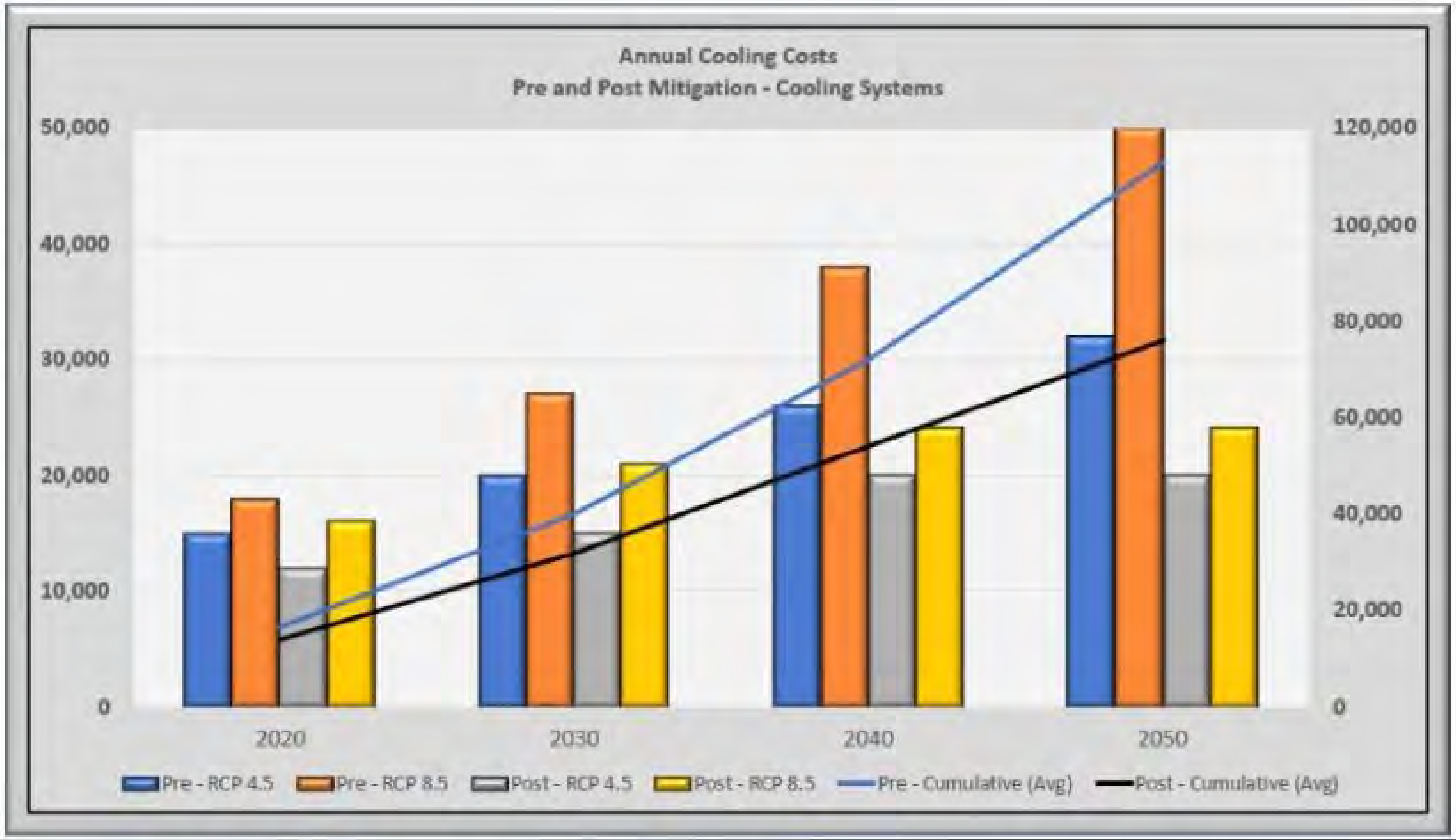
Adaptation Recommendations - The Climate Impact Analysis provides multiple standard and custom adaptation options to address multiple impact conditions

[TampaBay.mp4 - Google Drive]



Cost-Benefit Analysis - The Climate Impact Analysis provides a cost-benefit analysis to assist in determining whether a business-as-usual approach or an adaptation approach should be preferred

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Where to Start

- Understand appropriate use of climate models
- Find the vulnerabilities of concern for clients
- Understand the potential for operational impacts
- Where is your strategic benefit?

Conclusion

- Climate has always been an input to design – now include future projections instead of just historic
- Climate considerations require more than just awareness
- Every location in the United States has some future climate impact

Questions?

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