BUILDING INNOVATION
Conference

An Integrated Framework for Resilient Infrastructure Planning

Richard Graves, Director | Center for Sustainable Building Research
Ariane Laxo, Director of Sustainability | HGA

Agenda

- Introductions & Context
- Establishing a Framework for Resilience Infrastructure Planning
- Case Study Applications
- Q&A

Richard Graves

Director

Center for Sustainable Building Research

Ariane Laxo

Director of Sustainability

HGA

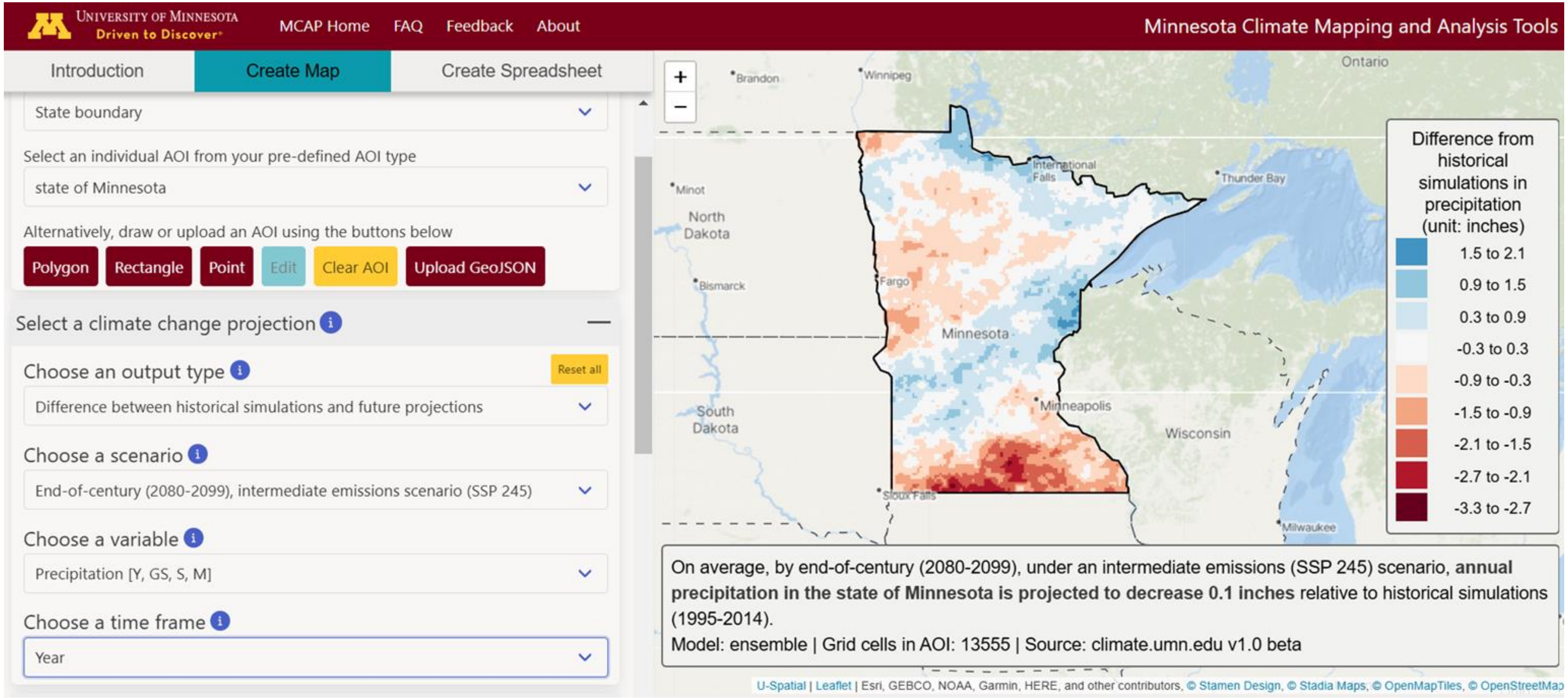
University of Minnesota Climate Adaptation Partnership

- **Focused on preparing for and adapting to** future climate conditions
- **Sector-specific** expertise
- **Research-based education** and **technical assistance**
- **Partnering across sectors and scales**

CFANS
COLLEGE OF FOOD, AGRICULTURAL AND NATURAL RESOURCE SCIENCES

UNIVERSITY OF MINNESOTA EXTENSION
Driven to Discover℠

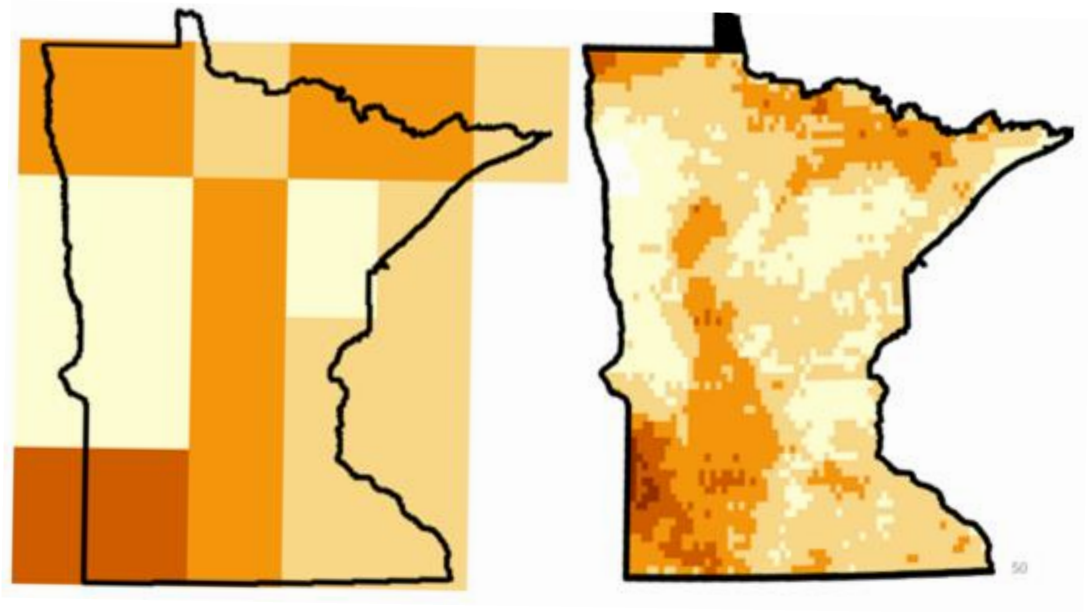
Minnesota Climate Mapping and Analysis Tool (MN CliMAT)



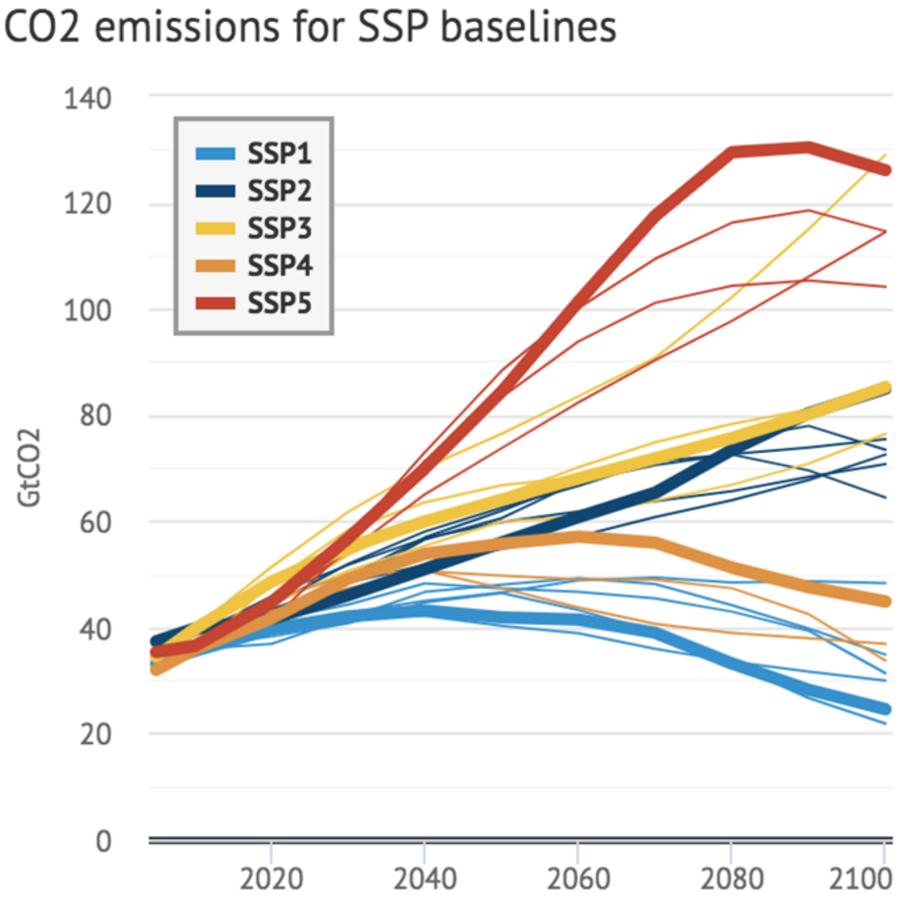
app.climate.umn.edu

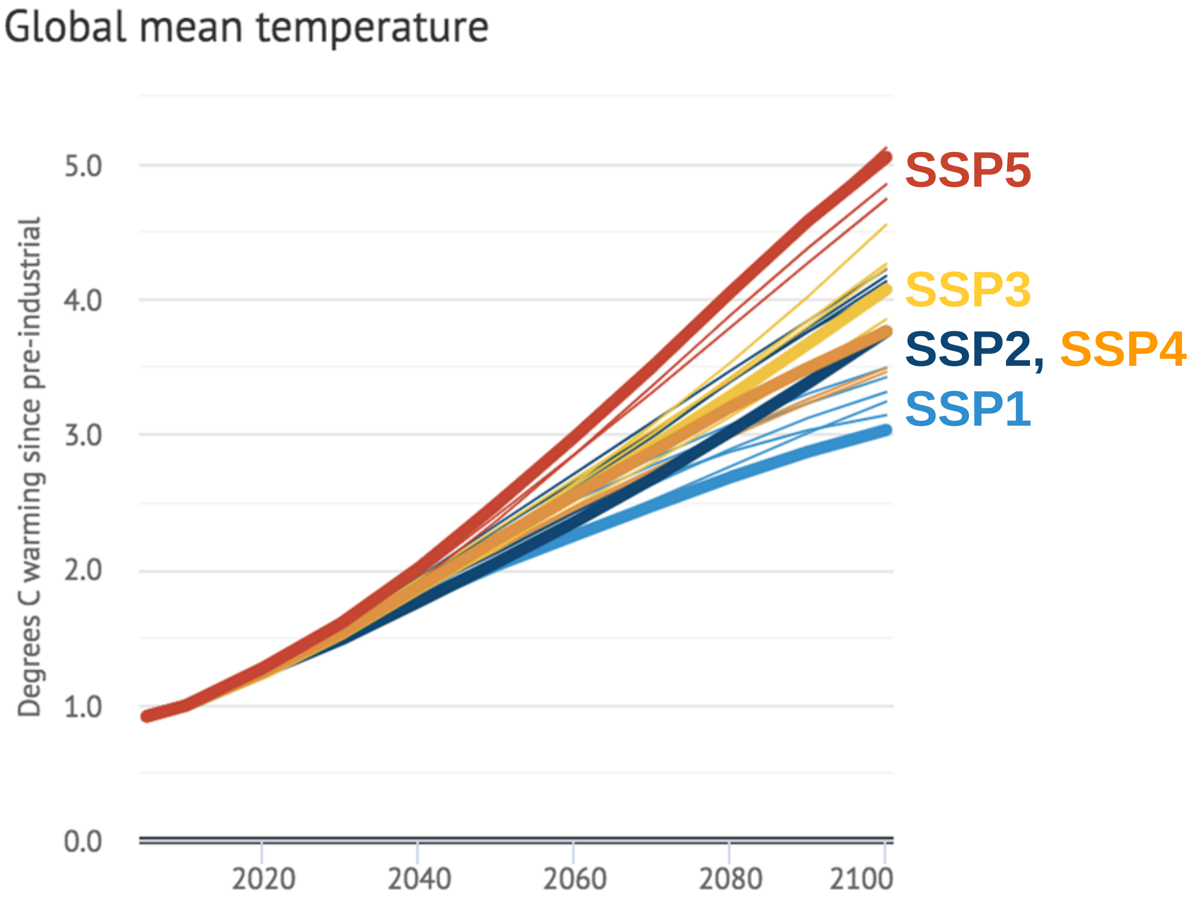
Minnesota Climate Mapping and Analysis Tool (MN CliMAT)

- Developed using 6 models from the latest generation of global climate models (CMIP6)
- Dynamical downscaled to create high-resolution data for Minnesota
- Incorporates a lake model to better capture lake effects on regional and local climate patterns



MN CliMAT provides **3 emissions scenarios**:

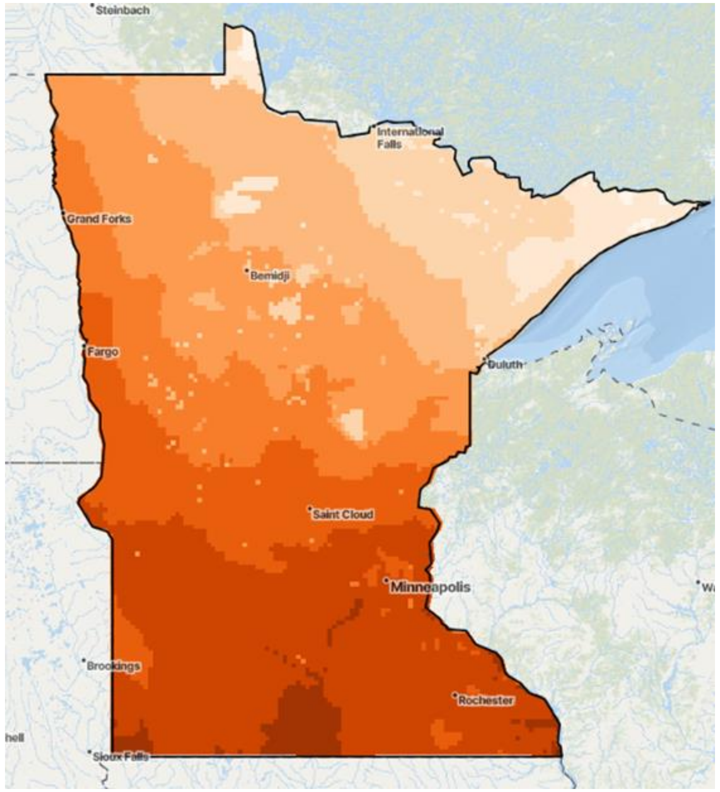




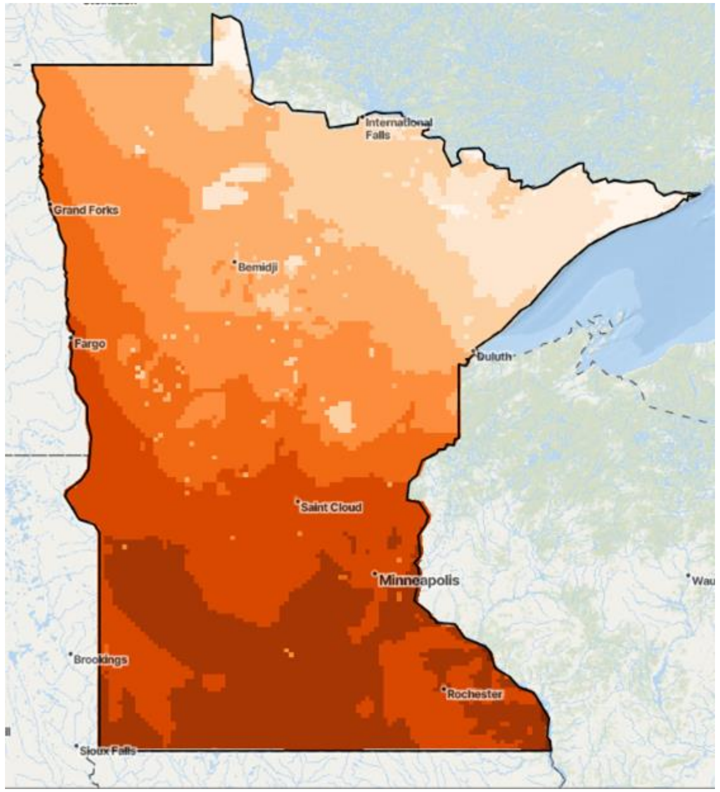
CB

MN CliMAT provides multiple **time scales**

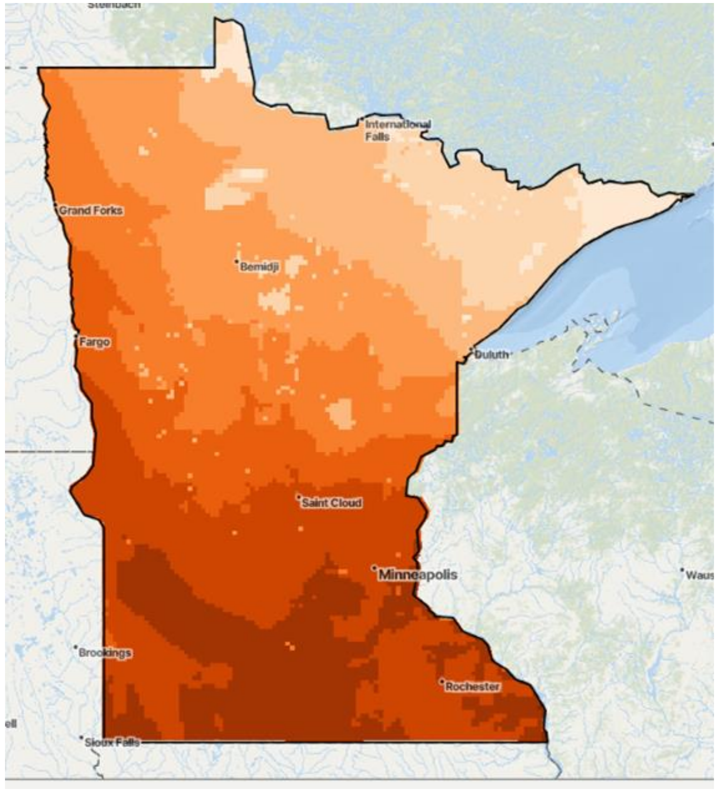
Daily maximum temperatures under an intermediate emissions scenario (SSP245)



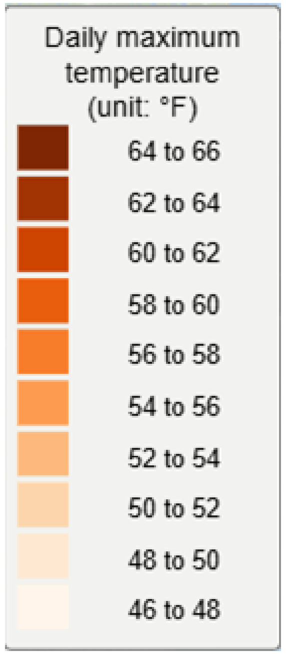
Mid-century (2040 - 2059)



Late century (2060 - 2079)

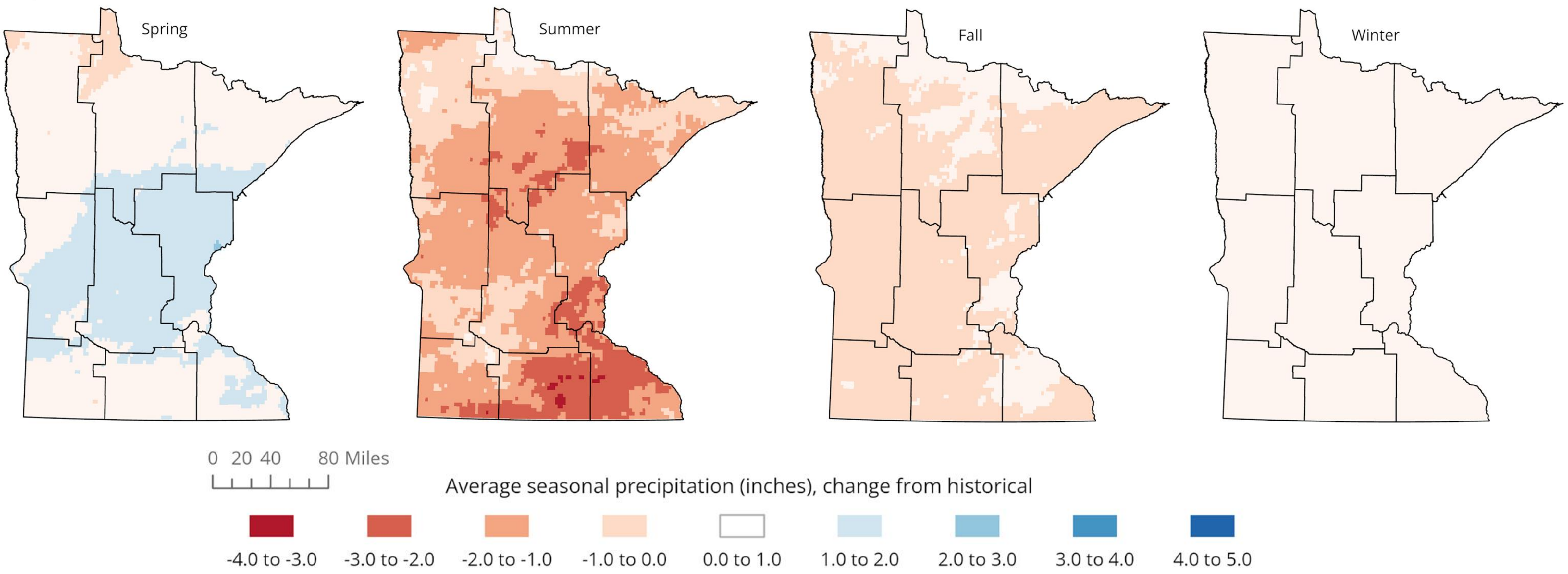


End-of-century (2080 - 2099)



MN CliMAT provides multiple **time scales**

Change in average precipitation by end-of-century (2080-2099) compared to historical simulations (1995 - 2014) under an intermediate emissions scenario (SSP245)



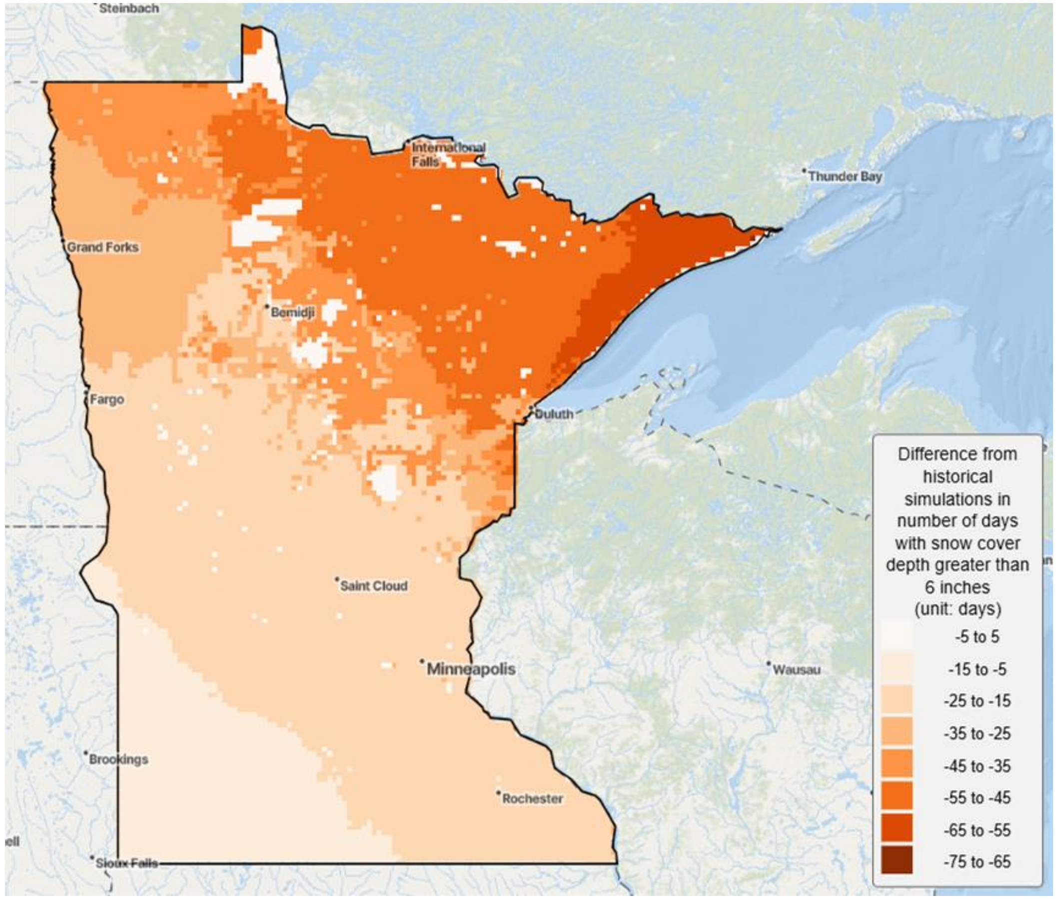
MN CliMAT provides
30+ variables

Precipitation values, thresholds, intensity:

- Precipitation
- # of days with precipitation greater than: 0.01, 1, and 2 inches
- Longest dry spell (growing season)
- Maximum 1-day to 7-day total precipitation

Snow:

- Snow cover depth
- # of days with snow cover depth greater than 1 inch & 6 inches



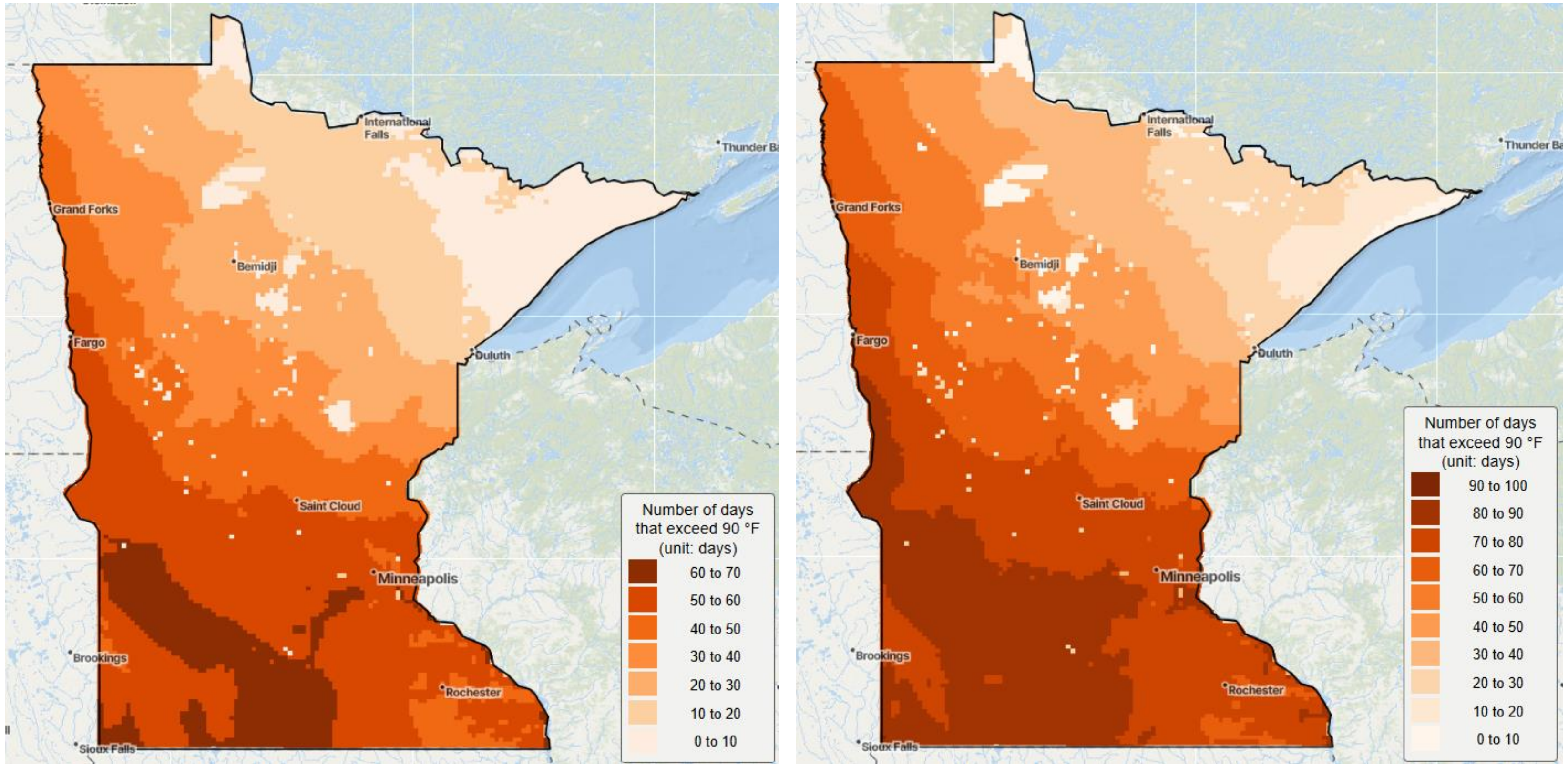
Difference in the number of days with snow cover depth greater than 6' under a very high emission scenario (SSP585) by end-of-century (2080 - 2099) compared to historical simulations (1995 - 2014)

MN CliMAT provides **30+ variables**

Temperature Averages
- Daily Maximum
- Daily Average
- Daily Minimum

and Thresholds:
- # of days with minimum temperatures above/below __F
- # of days with maximum temperatures above/below __F
- # of days that exceed (<u>90, 95, 100</u>) F

Humidity
- Relative Humidity



The number of days above 90 degrees F under an intermediate scenario (SSP245, left) and very high emission scenario (SSP585, right) by end-of-century (2080 - 2099)

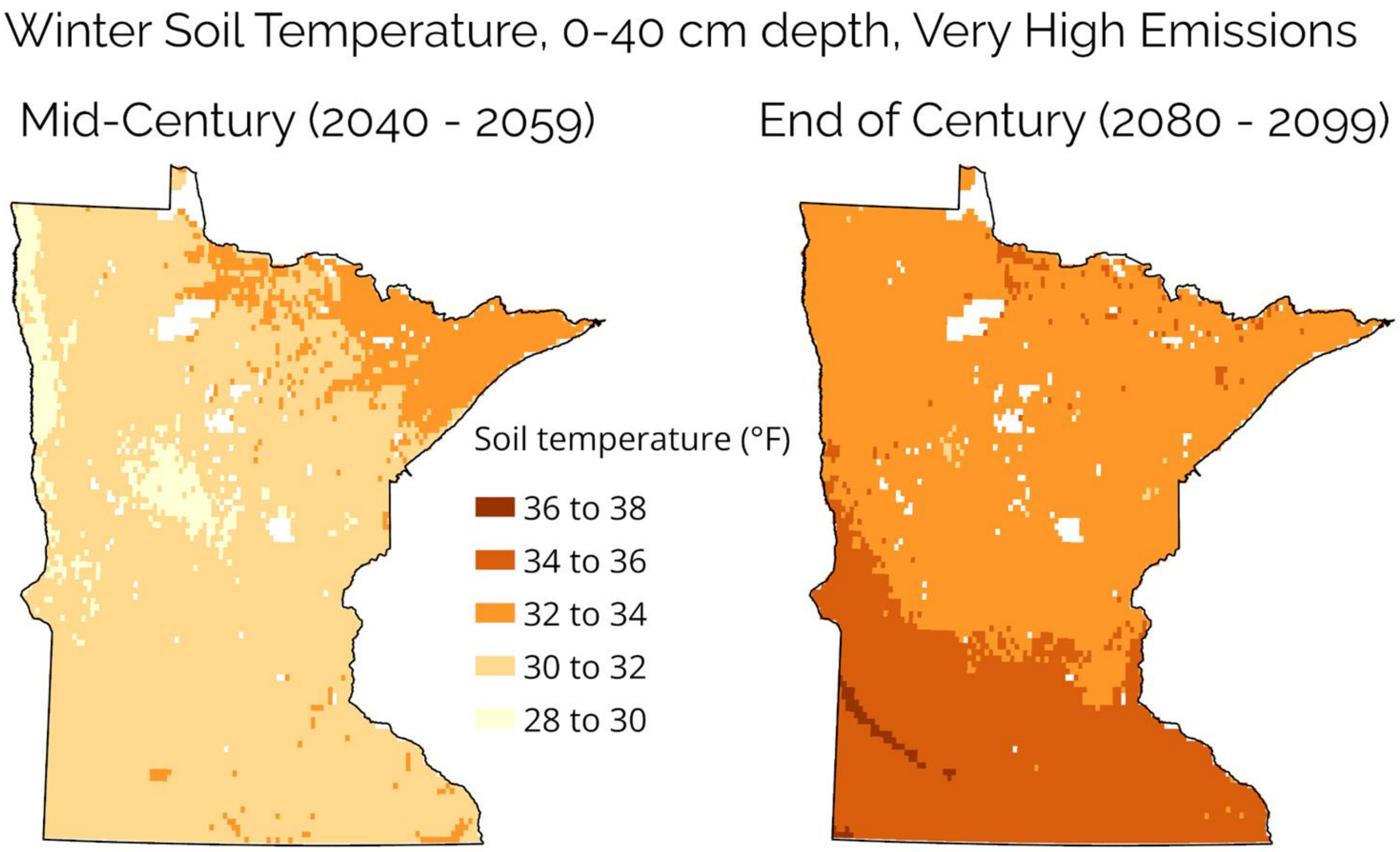
MN CliMAT provides **30+ variables:**

Soils:

- Soil temp at 4 depths
- Soil moisture at 4 depths

Lakes:

- Proportion of frozen lake surface
- Temperature at lake bottom



Minnesota Resilience Report - 2025

In the 2023 Legislative session, a bill was passed to conduct research examining how projections of future weather trends may exacerbate climate conditions, including but not limited to drought, elevated temperatures, and flooding that:

(1) can be integrated into the design and evaluation of buildings constructed by the state of Minnesota and local units of government, in order to:

(i) reduce energy costs by deploying cost-effective energy efficiency measures, innovative construction materials and techniques, and renewable energy sources; and

(ii) prevent and minimize damage to buildings caused by extreme weather conditions, including but not limited to increased frequency of intense precipitation events and tornadoes, flooding, and elevated temperatures; and

(2) may weaken the ability of natural systems to mitigate the conditions to the point where human intervention in the form of building or redesigning the scale and operation of infrastructure is required to address those conditions in order to:

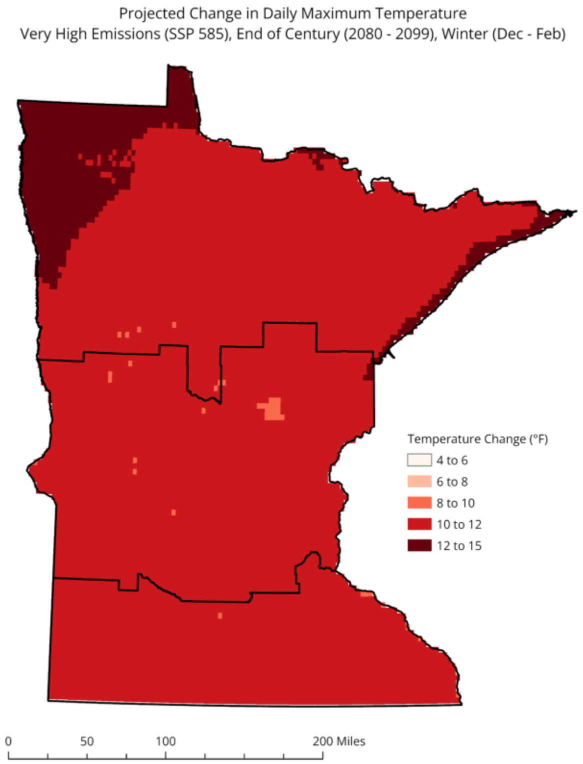
(i) maintain and increase the amount and quality of food and wood production;

(ii) reduce fire risk on forested land;

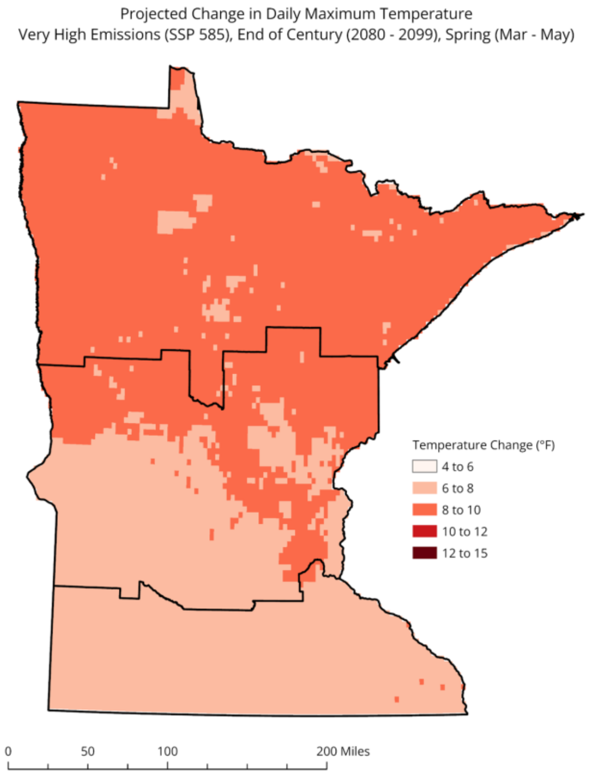
(iii) maintain and enhance water quality; and

(iv) maintain and enhance natural habitats.

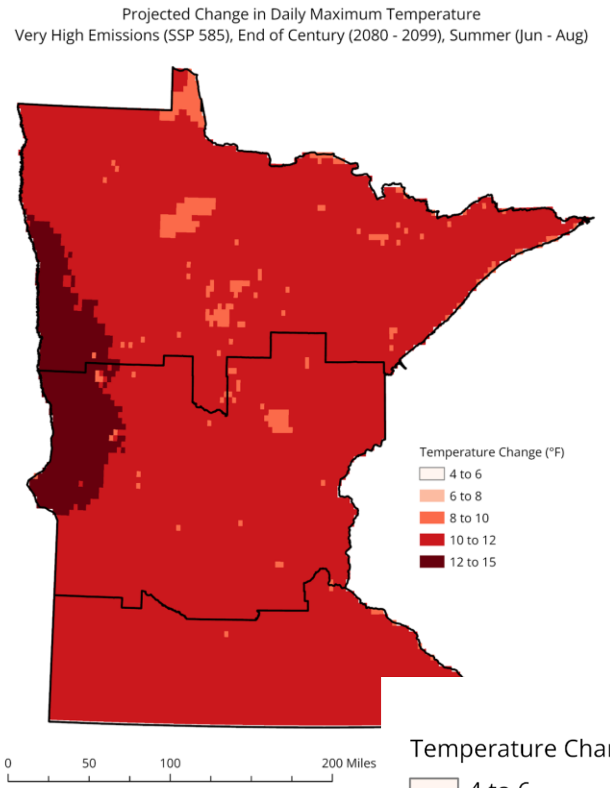
Very High Emissions: SSP585 (End) Daily Max Temp



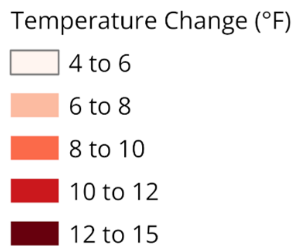
Winter

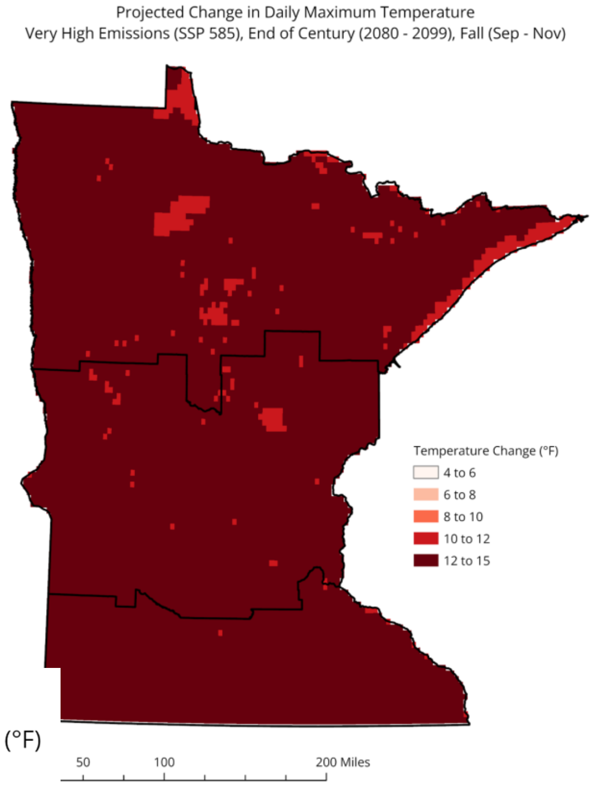


Spring



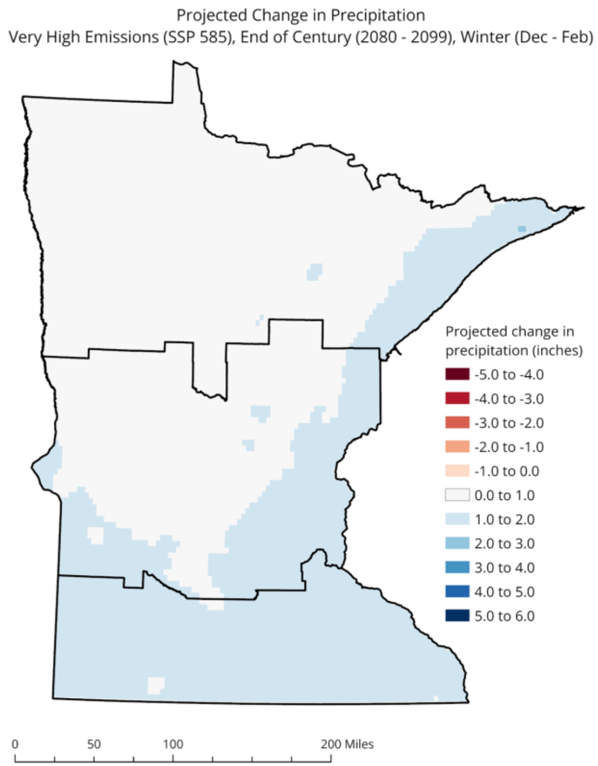
Summer



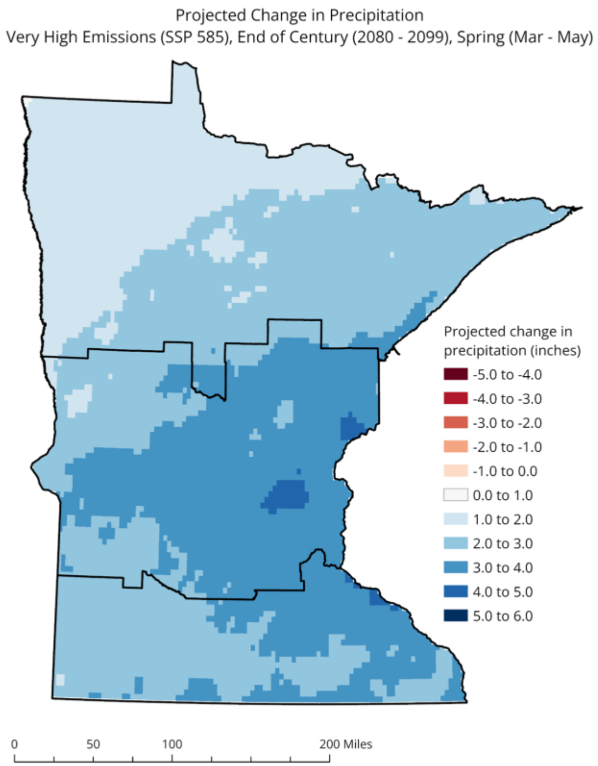


Fall

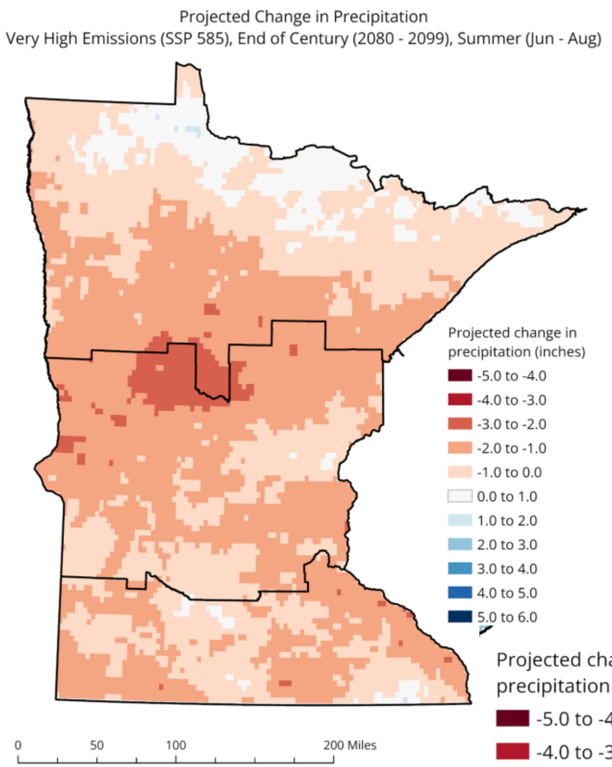
SSP585 (End) Precipitation



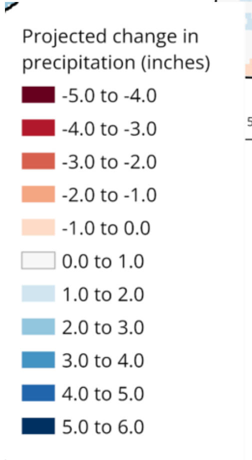
Winter

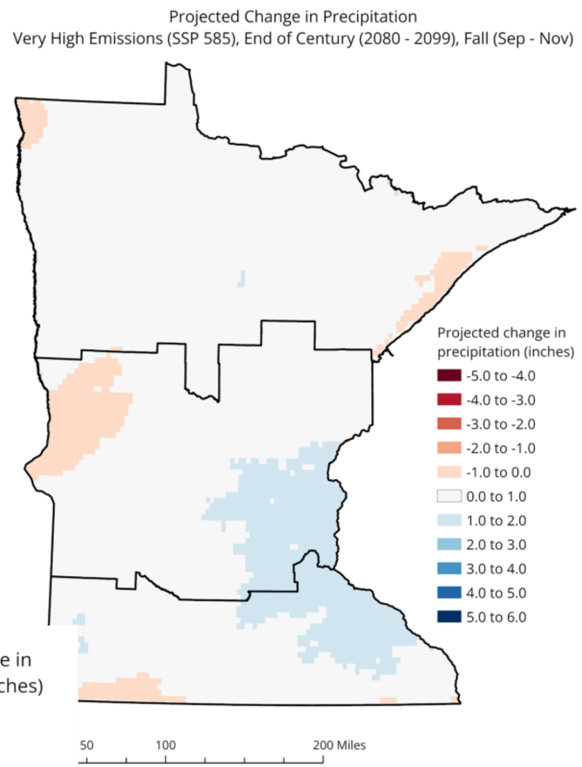


Spring



Summer





Fall

Analyzing infrastructure as a complex social, ecological, and technological system can reveal overlooked climate actions.

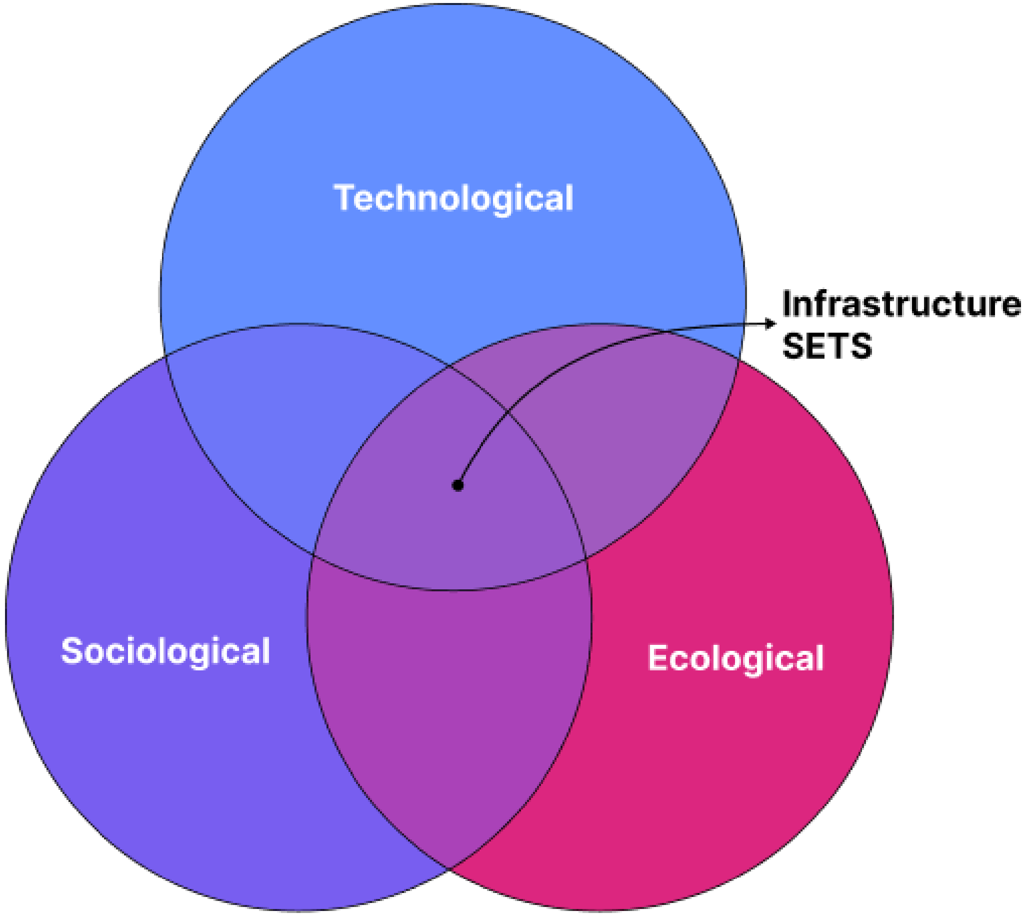
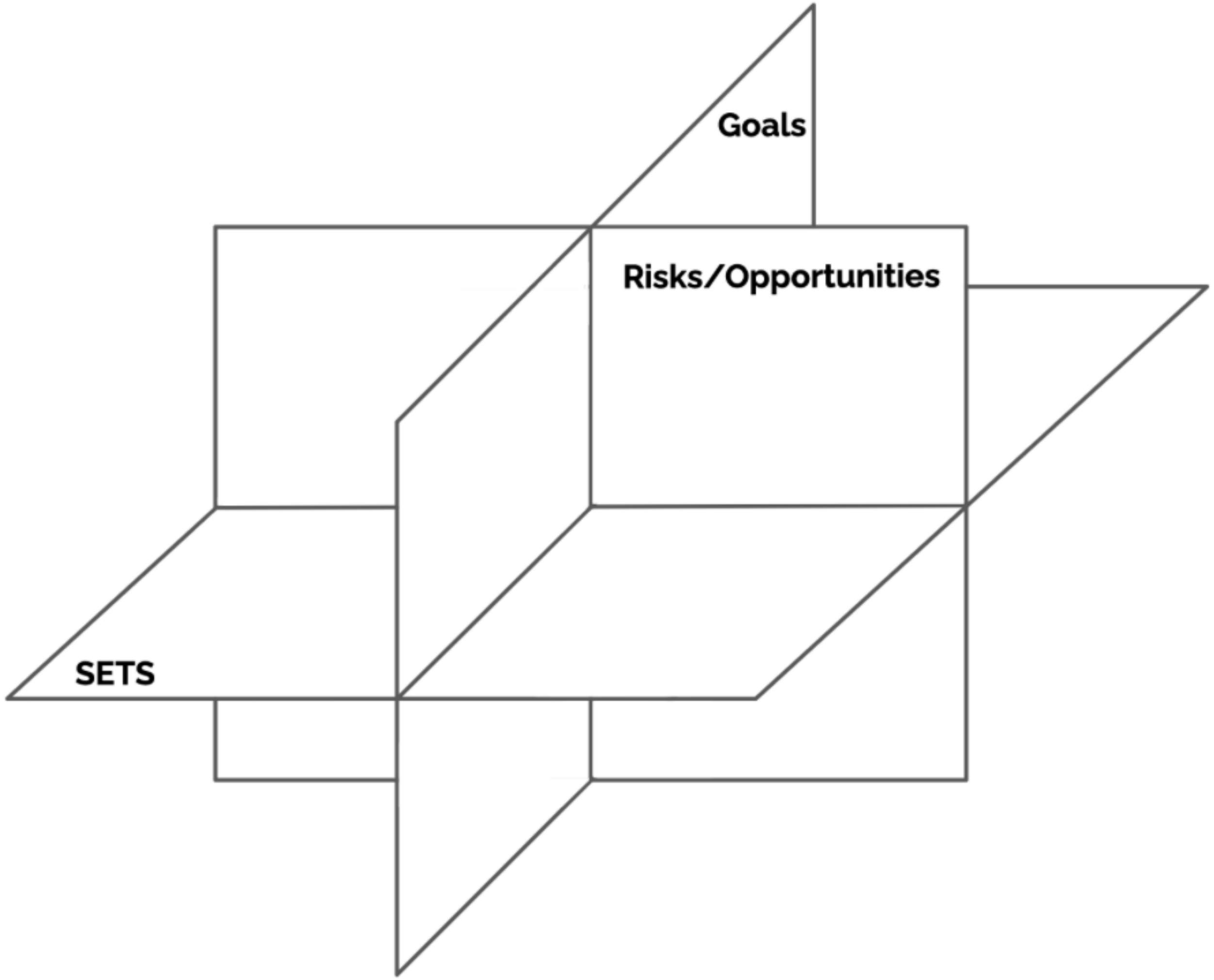


Fig. 1 Infrastructure SETS map

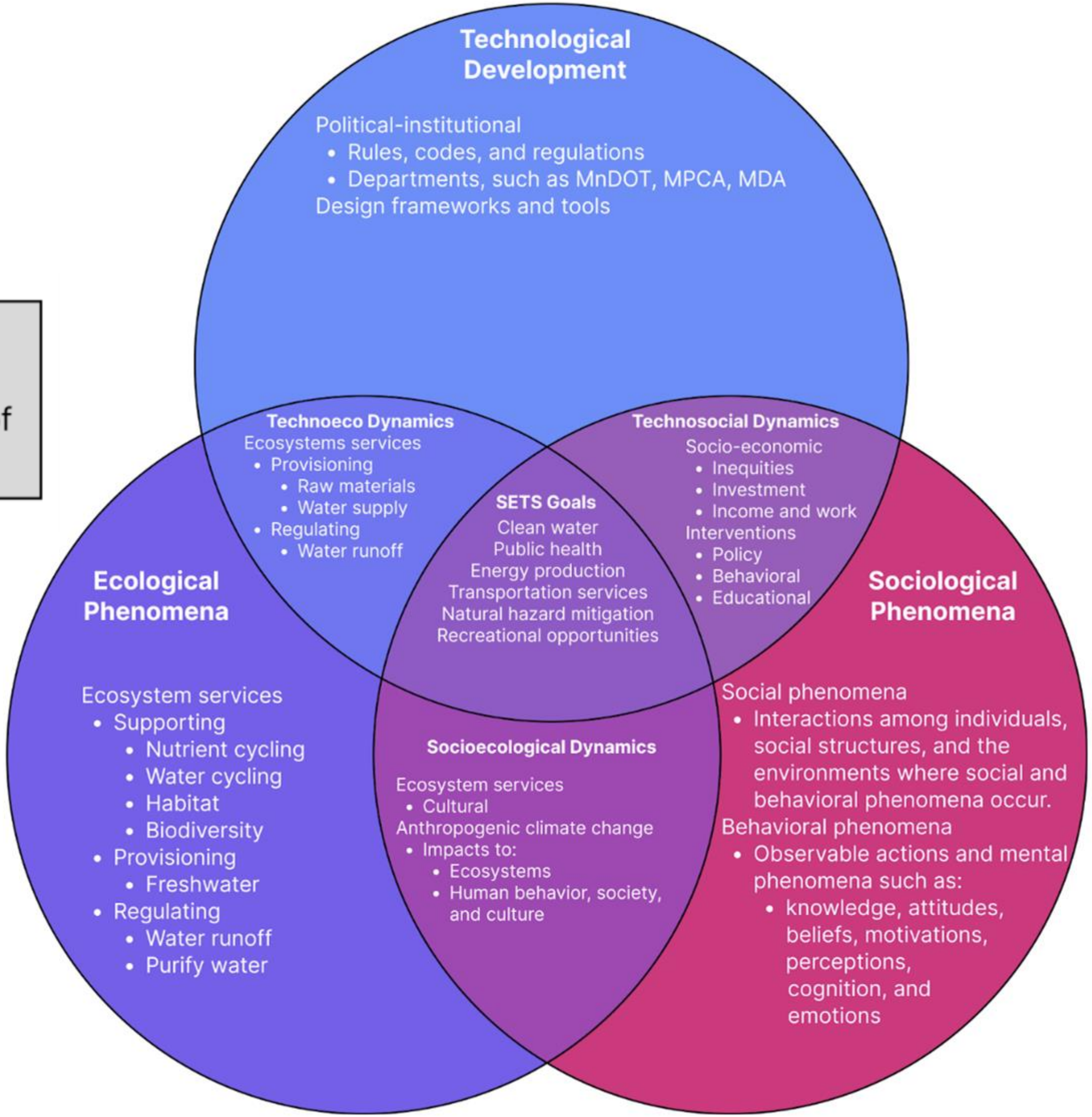
- Anticipates complex and interconnected risks to infrastructure systems and the policies that guide their design and use.
- Captures the benefits, trade offs, and opportunities of decisions through integrated infrastructure planning.
- Models the capacity of policy responses to meet current infrastructure goals while ensuring resilient policy capacity to the range of potential climate futures.

Map the relationship of the infrastructure SETS, goals and risk



Map the relationship of the infrastructure SETS, goals ar risk

Built environment infrastructure includes all built or intentionally used ecological phenomena that support the design, construction, operations, or, maintenance of built infrastructure.



Watershed Scale Analysis

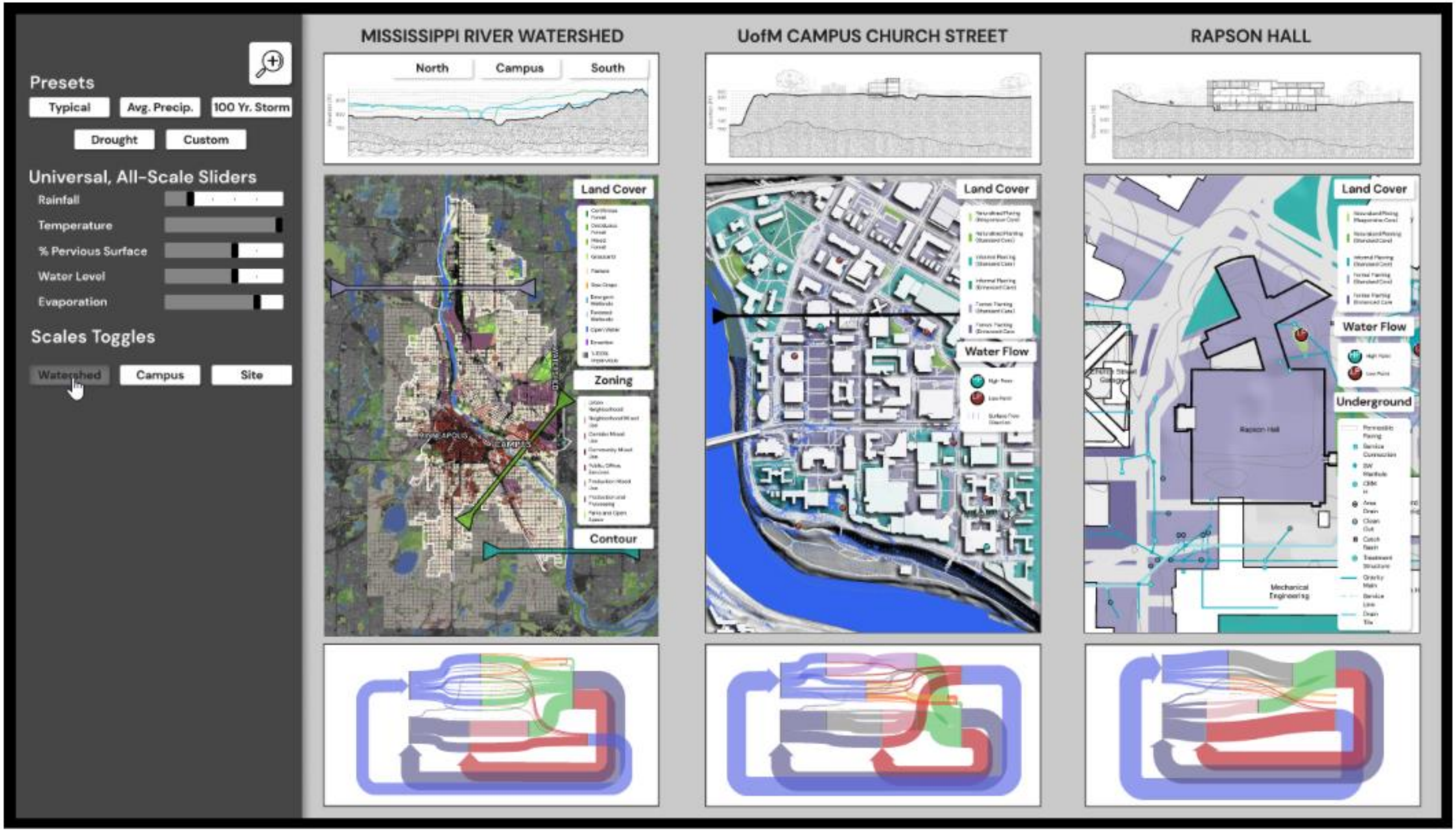
We want to assess water-based climate change effects at the watershed, subwatershed (huc8), the district scale, and the building/site scale.

Utilizing the watershed boundary creates more realistic values for the aggregate effects that future weather/water will have because watersheds are contained geologically.

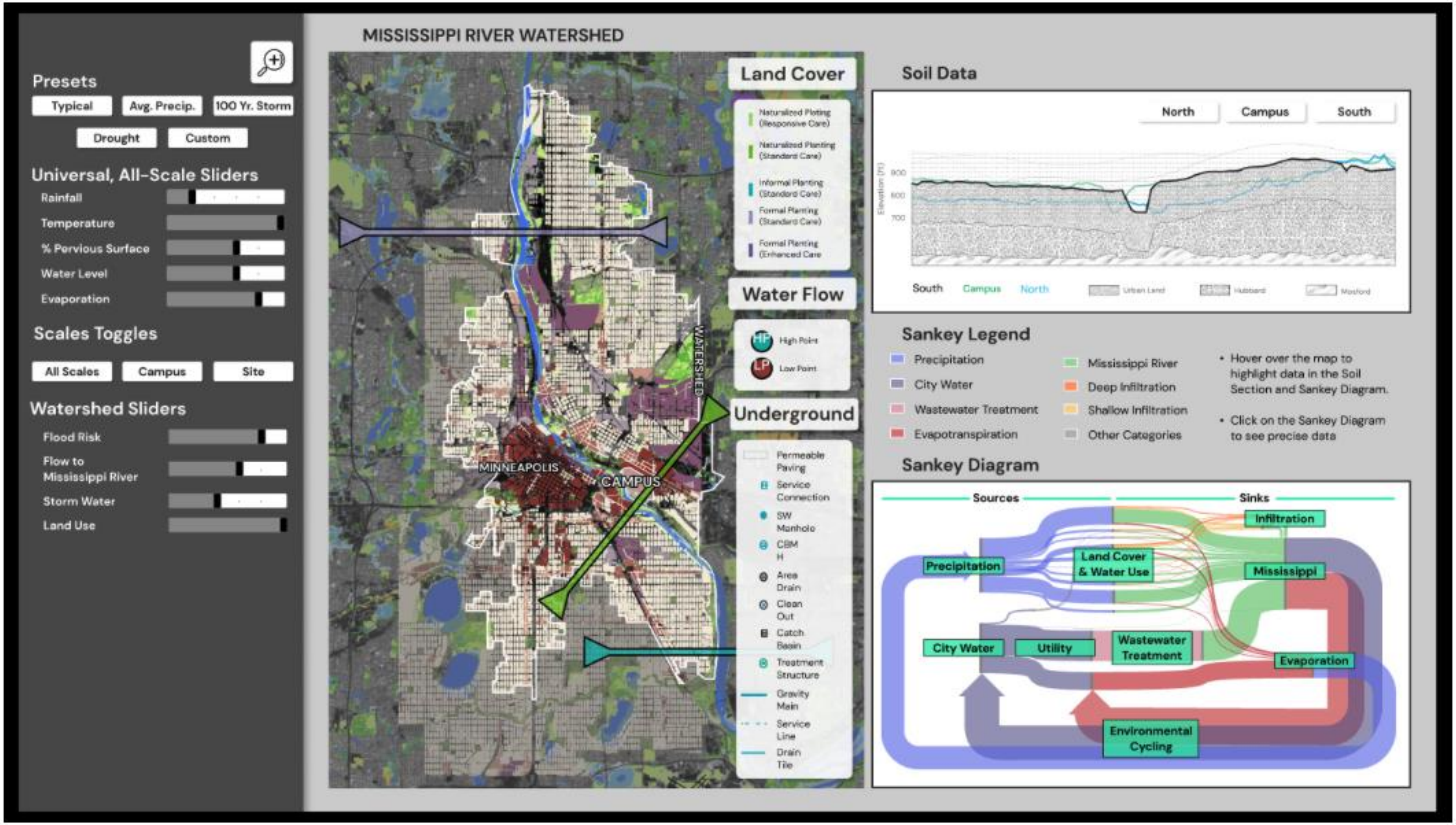
These watershed scale analysis will hopefully be more useful to watershed managers when identifying priorities for resilient design and policy within their own watershed.

Basins and Major Watersheds in Minnesota

https://minnesotawaterstewards.org/your-watershed/mn-watersheds-jpg-2-2/



Presets
Typical
Avg. Precip.
100 Yr. Storm
Drought
Custom
Universal, All-Scale Sliders
Rainfall
Temperature
% Pervious Surface
Water Level
Evaporation
Scales Toggles
Watershed
Campus
Site
MISSISSIPPI RIVER WATERSHED
North
Campus
South
Land Cover
Zoning
Contour
UofM CAMPUS CHURCH STREET
Land Cover
Water Flow
RAPSON HALL
Land Cover
Water Flow
Underground
Rapson Hall
Mechanical Engineering


MISSISSIPPI RIVER WATERSHED
Presets
Typical
Avg. Precip.
100 Yr. Storm
Drought
Custom
Universal, All-Scale Sliders
Rainfall
Temperature
% Pervious Surface
Water Level
Evaporation
Scales Toggles
All Scales
Campus
Site
Watershed Sliders
Flood Risk
Flow to Mississippi River
Storm Water
Land Use
MINNEAPOLIS
CAMPUS
WATERSHED
Land Cover
Water Flow
High Point
Low Point
Underground
Permeable Paving
Service Connection
SW Manhole
Area Drain
Clean Out
Catch Basin
Treatment Structure
Gravity Main
Service Line
Drain Tile
Soil Data
North
Campus
South
Sankey Legend
Precipitation
City Water
Wastewater Treatment
Evapotranspiration
Mississippi River
Deep Infiltration
Shallow Infiltration
Other Categories
• Hover over the map to highlight data in the Soil Section and Sankey Diagram.
• Click on the Sankey Diagram to see precise data
Sankey Diagram
Sources
Sinks
Infiltration
Precipitation
Land Cover & Water Use
Mississippi
City Water
Utility
Wastewater Treatment
Evaporation
Environmental Cycling

Annual | **2100 - High Emmissions**

SITE #1 University of Minnesota -Twin Cities

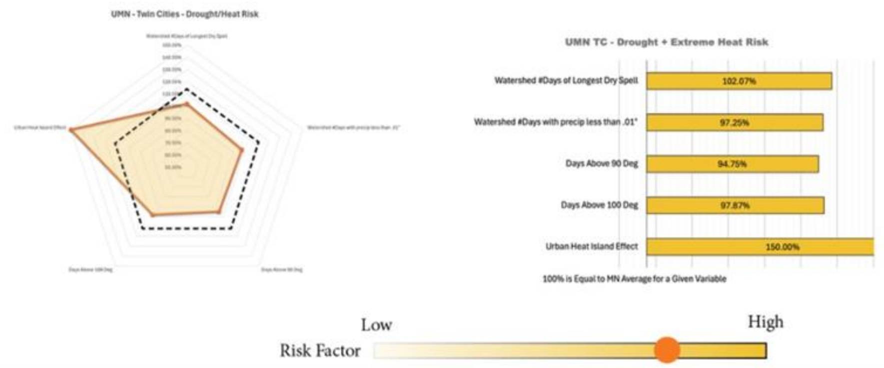
Hydrological Soil Group:..........................A 0% B 0% C 50% D 50%
Elevation:..807ft ASL
GPS Coords:...112985.22 N 125934.22 E
Nearest Waterbody:...................................Mississippi River
Distance to Receiving Waterbody:...........0.75 mi
Watershed:..MWMO
Elev. in Watershed:....................................Uplands
Surrounding Land Use:...............................Commercial
Rural/Urban/Natural:..................................Urban

Homeland Security Region: 6

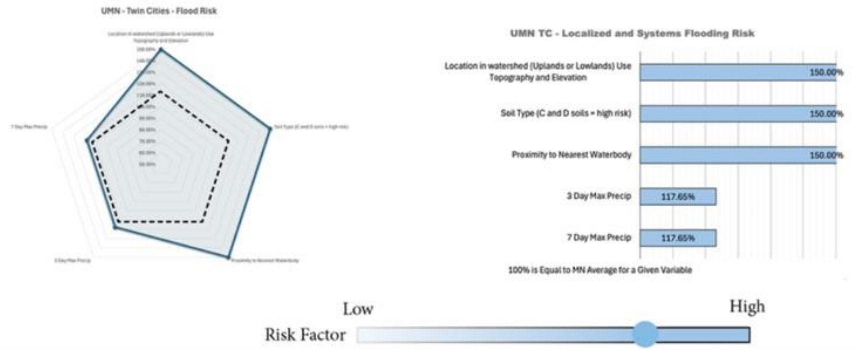
HUC8 Watershed: MWMO

NOAA Climate Region: EC

DROUGHT/HEAT



FLOOD/EXCESS PRECIP



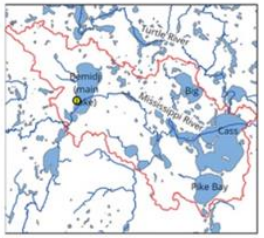
SITE/CONTEXT FACTORS

ELEVATION

Elevation (meters above sea level)

- 591 - 863
- 864 - 985
- 986 - 1,087
- 1,088 - 1,181
- 1,182 - 1,272
- 1,273 - 1,362
- 1,363 - 1,464
- 1,465 - 1,598
- 1,599 - 1,769
- 1,770 - 2,300

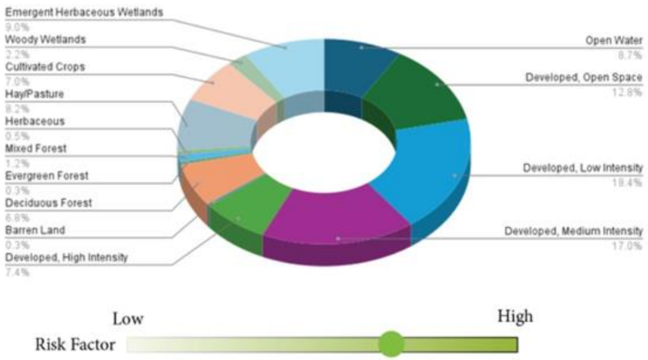
WATERBODIES



- Rivers and Streams
- Lakes
- BSU - Bemidji
- HUC 10 Watershed Name
- Cass Lake-Mississippi River

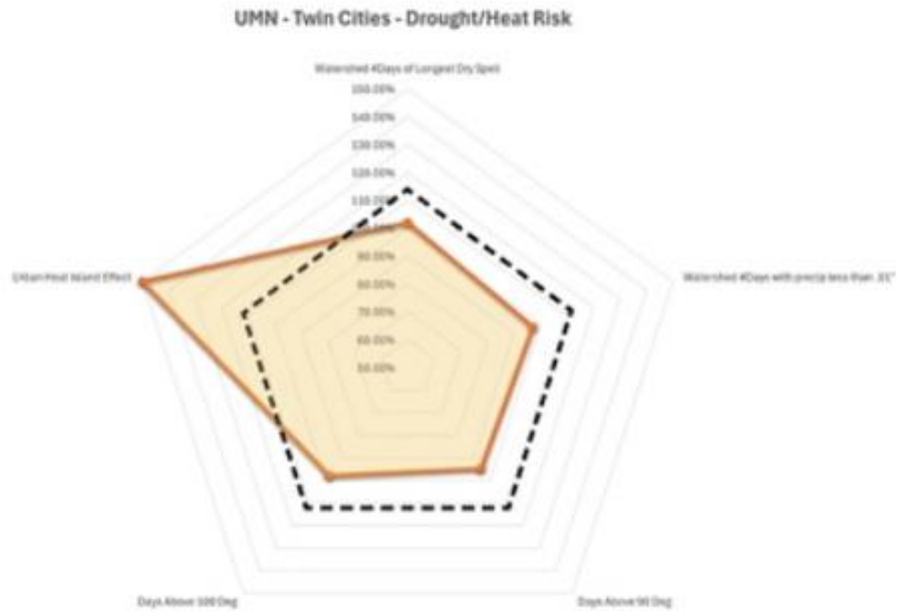
LAND COVER/USE

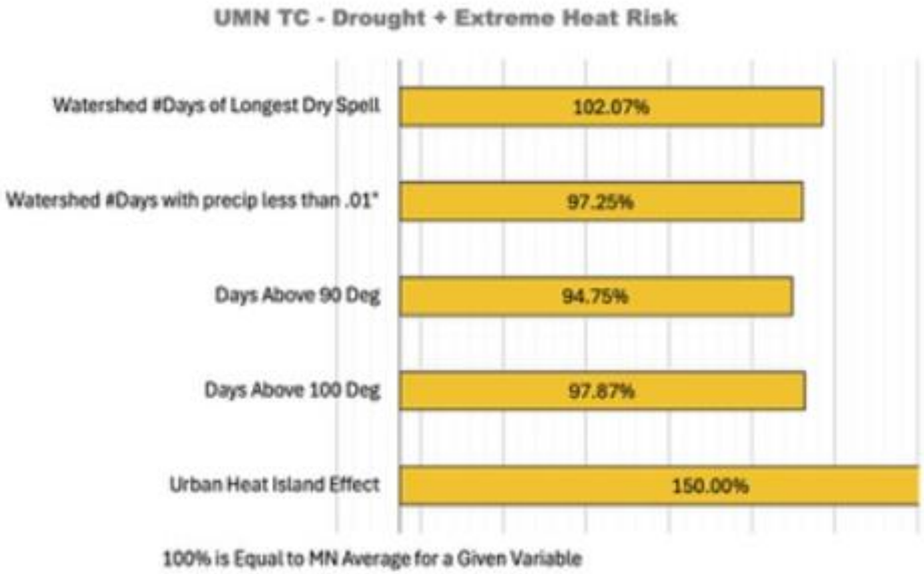
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Emergent Herbaceous Wetlands
- Shrub/Scrub
- Herbaceous
- Hay/Pasture
- Cultivated Crops
- Woody Wetlands
- Open Water
- Barren Land



Annual | 2100 - High Emmissions

DROUGHT/HEAT

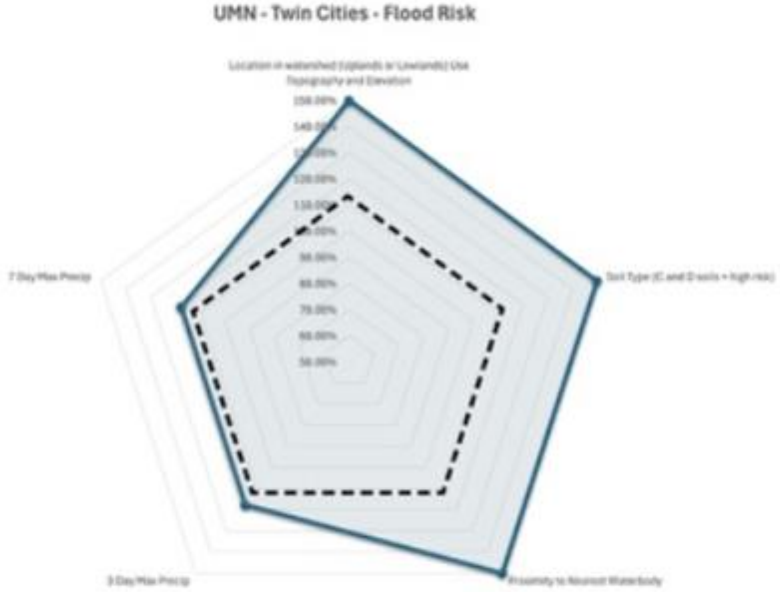


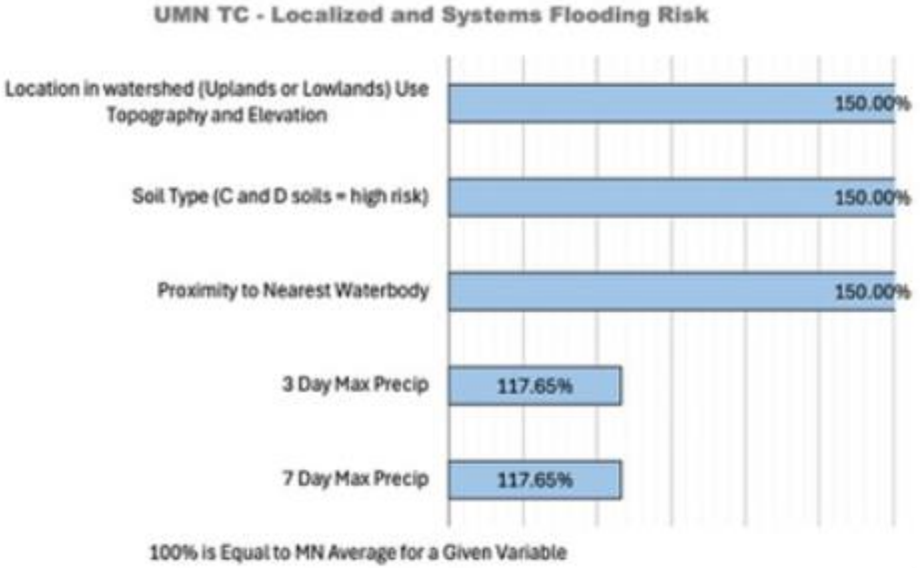


Low | High

Risk Factor

FLOOD/EXCESS PRECIP





Annual | 2100 - High Emmissions

SITE #4 Bemidji State University

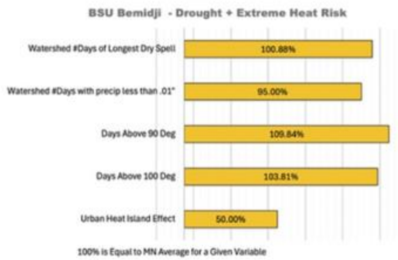
Hydrological Soil Group:..........................A 0% B 0% C 100% D 0%
Elevation:..807ft ASL
GPS Coords:...47.48421478 -94.87145831
Nearest Waterbody:...............................Lake Bemidji
Distance to Receiving Waterbody:...........0.79 mi
Watershed:..Mississippi River Hdwtrs
Elev. in Watershed:.................................Lowlands
Surrounding Land Use:...........................Commercial
Rural/Urban/Natural:...............................Urban


Homeland Security Region: 2

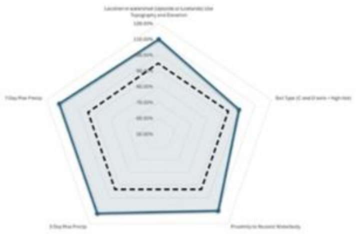

HUC8 Watershed: MR HDWTRS

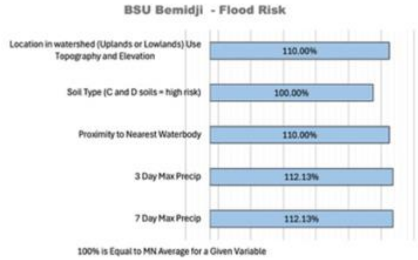
NOAA Climate Region: NC

DROUGHT/HEAT



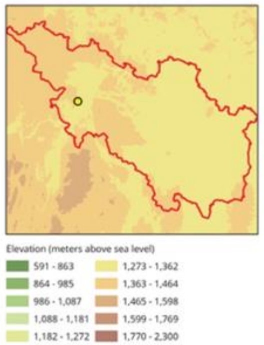
FLOOD/EXCESS PRECIP





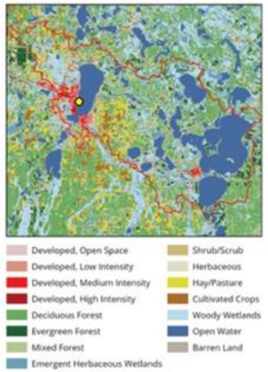
SITE/CONTEXT FACTORS

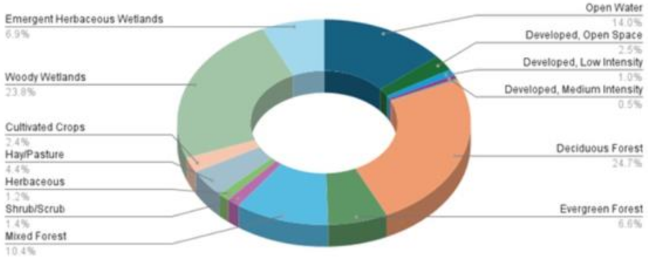
ELEVATION



WATERBODIES

LAND COVER/USE





Annual | 2100 - High Emmissions

SITE #3 Mankato State University

Hydrological Soil Group:..........................A 0% B 100% C 0% D 0%
Elevation:...608ft ASL
GPS Coords:..44.14479828 -93.99917371
Nearest Waterbody:.................................Lake Bemidji
Distance to Receiving Waterbody:...........2.35 mi
Watershed:...Minnesota River - Mankato
Elev. in Watershed:..................................Lowlands
Surrounding Land Use:............................Commercial
Rural/Urban/Natural:................................Urban

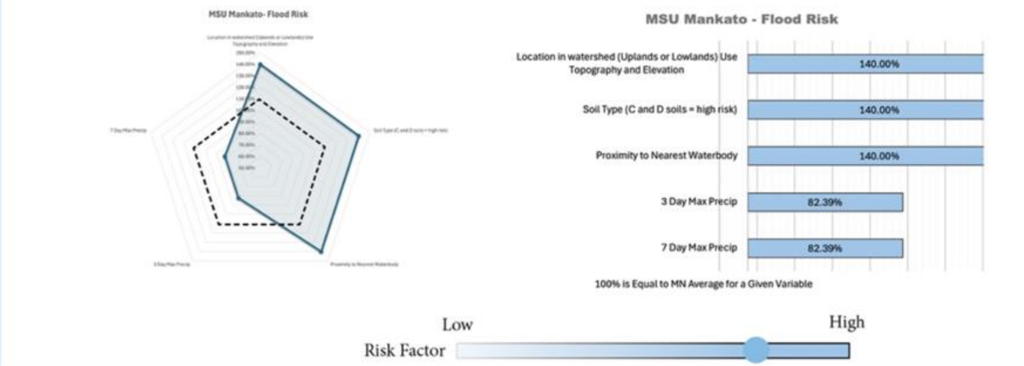
Homeland Security Region: 1

HUC8 Watershed: MN River Mankato

NOAA Climate Region: SC

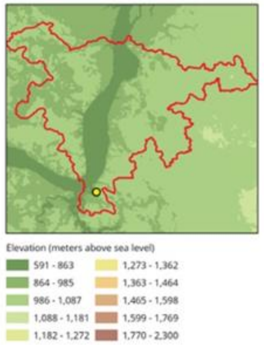
DROUGHT/HEAT

FLOOD/EXCESS PRECIP



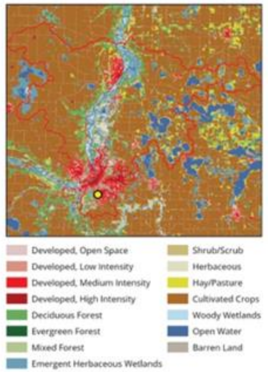
SITE/CONTEXT FACTORS

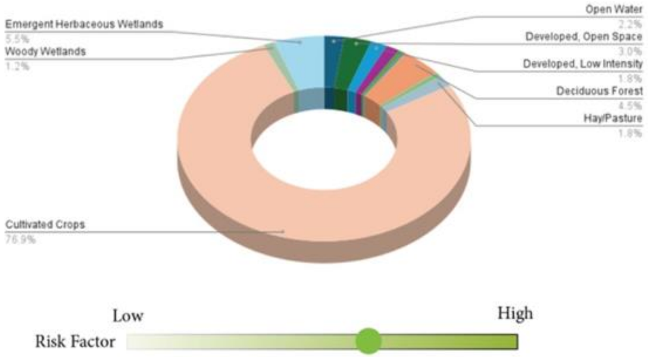
ELEVATION



WATERBODIES

LAND COVER/USE





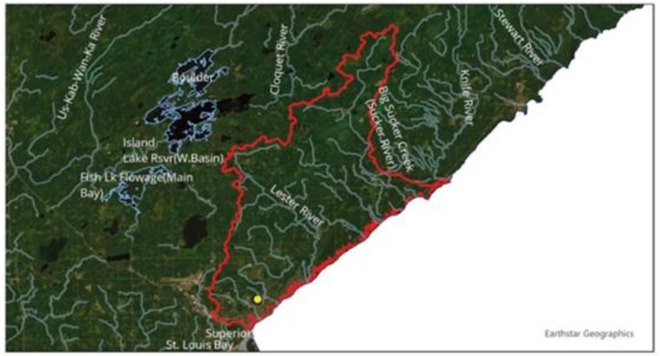
SITE #8 UMN - Duluth

Hydrological Soil Group:........................A 0% B 100% C 0% D 0%
Elevation:..906ft ASL
GPS Coords:...46.82038116 -92.08526632
Nearest Waterbody:................................Tisher Creek
Distance to Receiving Waterbody:...........1.6 mi
Watershed:...St Louis River
Elev. in Watershed:................................Uplands
Surrounding Land Use:...........................Developed/Open
Rural/Urban/Natural:..............................Urban

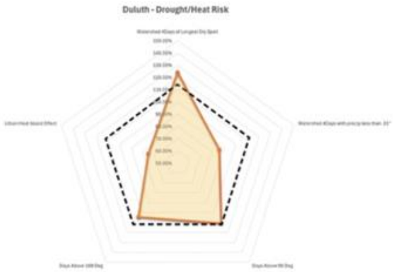
Homeland Security Region: 2

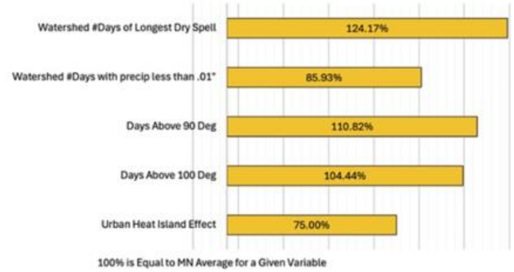
HUC8 Watershed: ST. LOUIS RIV

NOAA Climate Region: NE

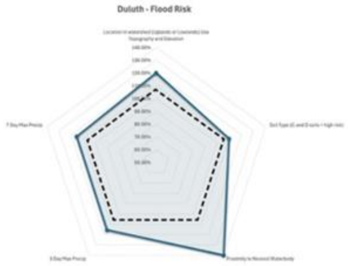


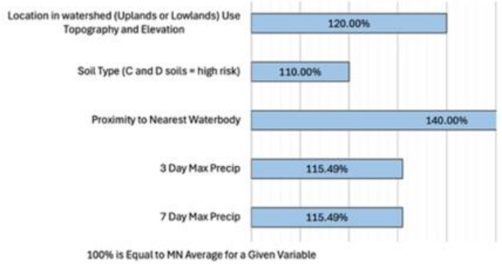
DROUGHT/HEAT





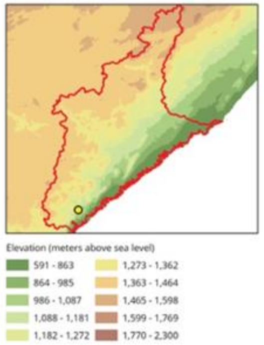
FLOOD/EXCESS PRECIP





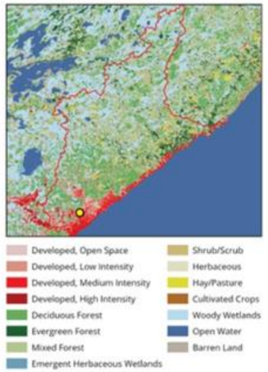
SITE/CONTEXT FACTORS

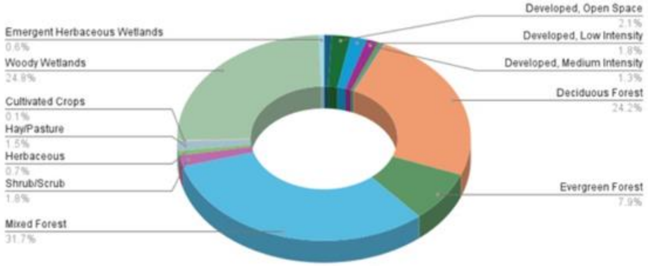
ELEVATION



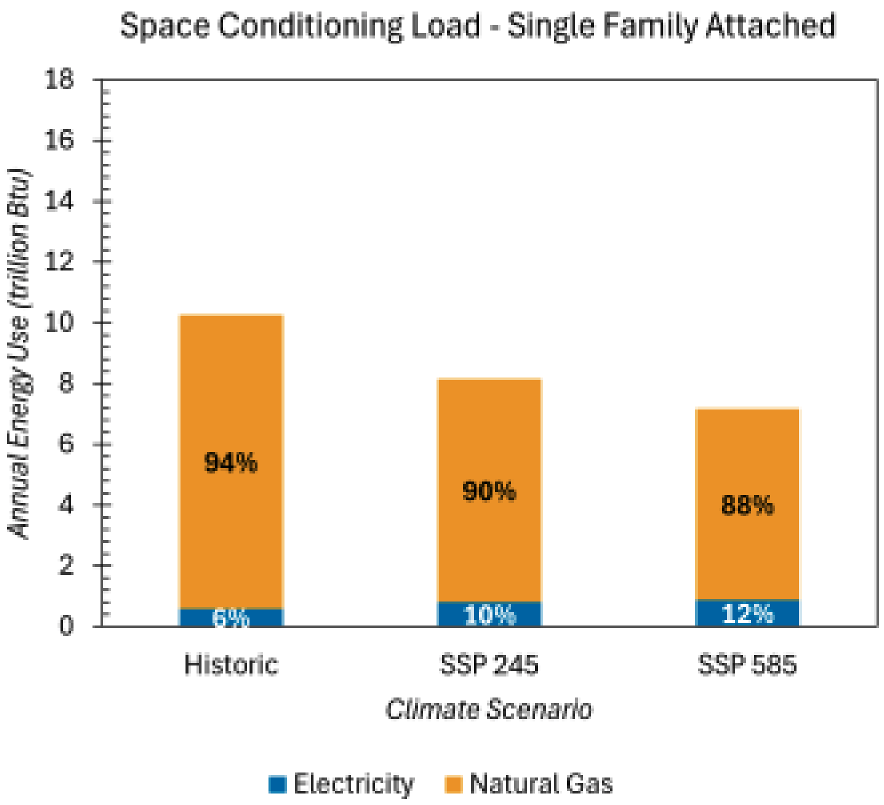
WATERBODIES

LAND COVER/USE





Building Energy Design Scenarios



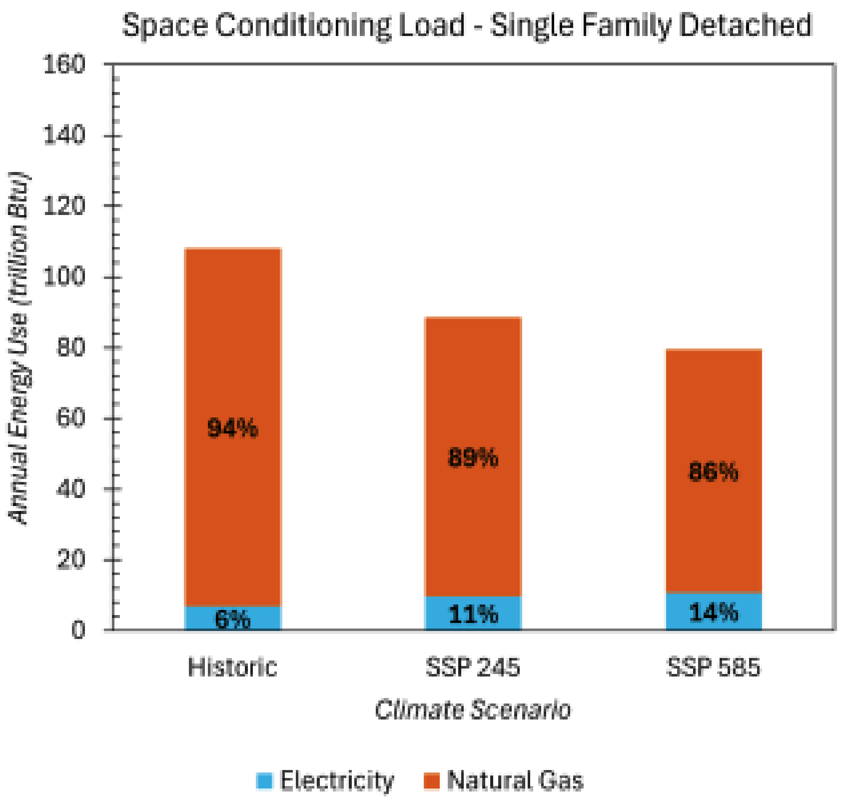


Figure 5.1: Modeled annual space conditioning loads by energy source for single family attached and single family detached homes in the Metro Area.

Building Energy Design Scenarios

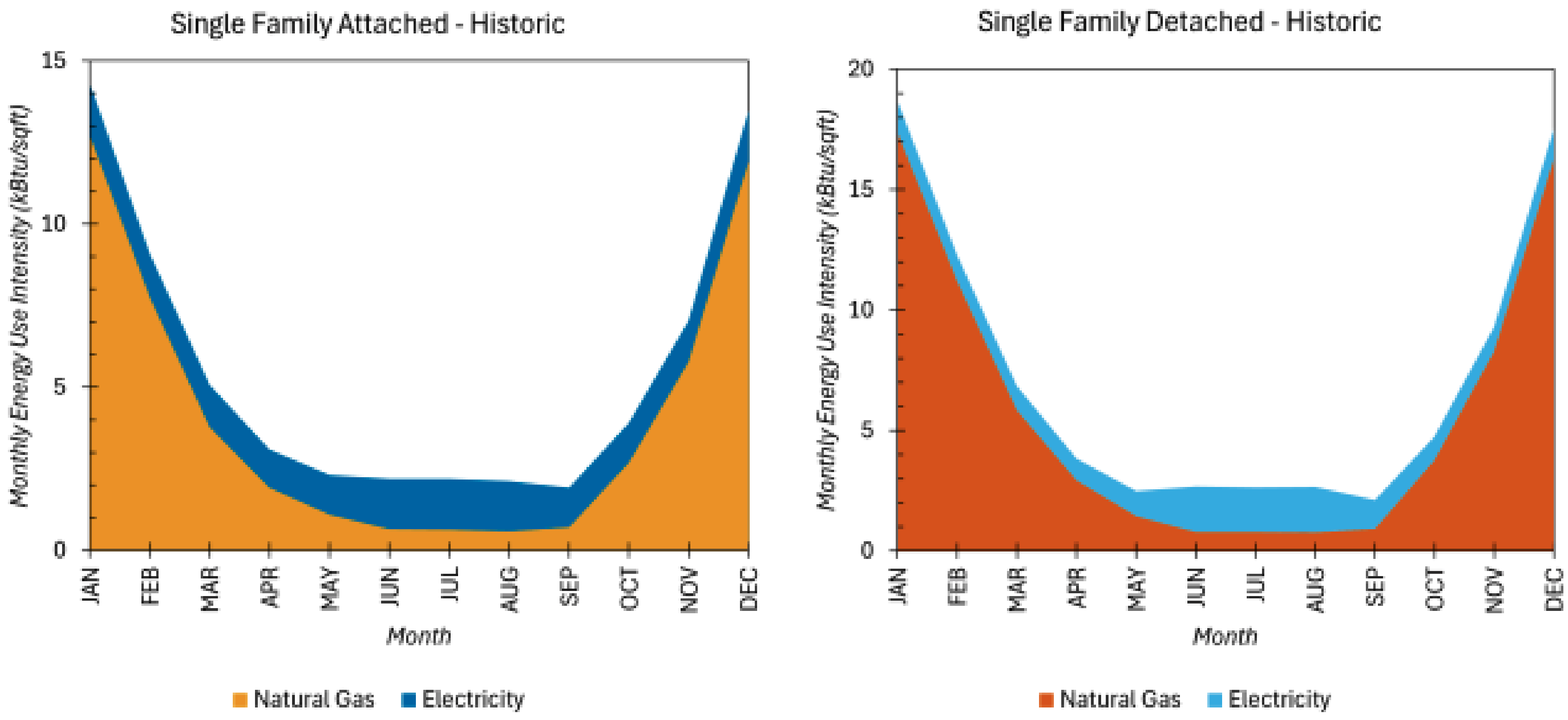


Figure 5.2: Modeled monthly space conditioning loads by energy source for single family attached and single family detached homes in the Metro Area under historic conditions.

Building Energy Design Scenarios

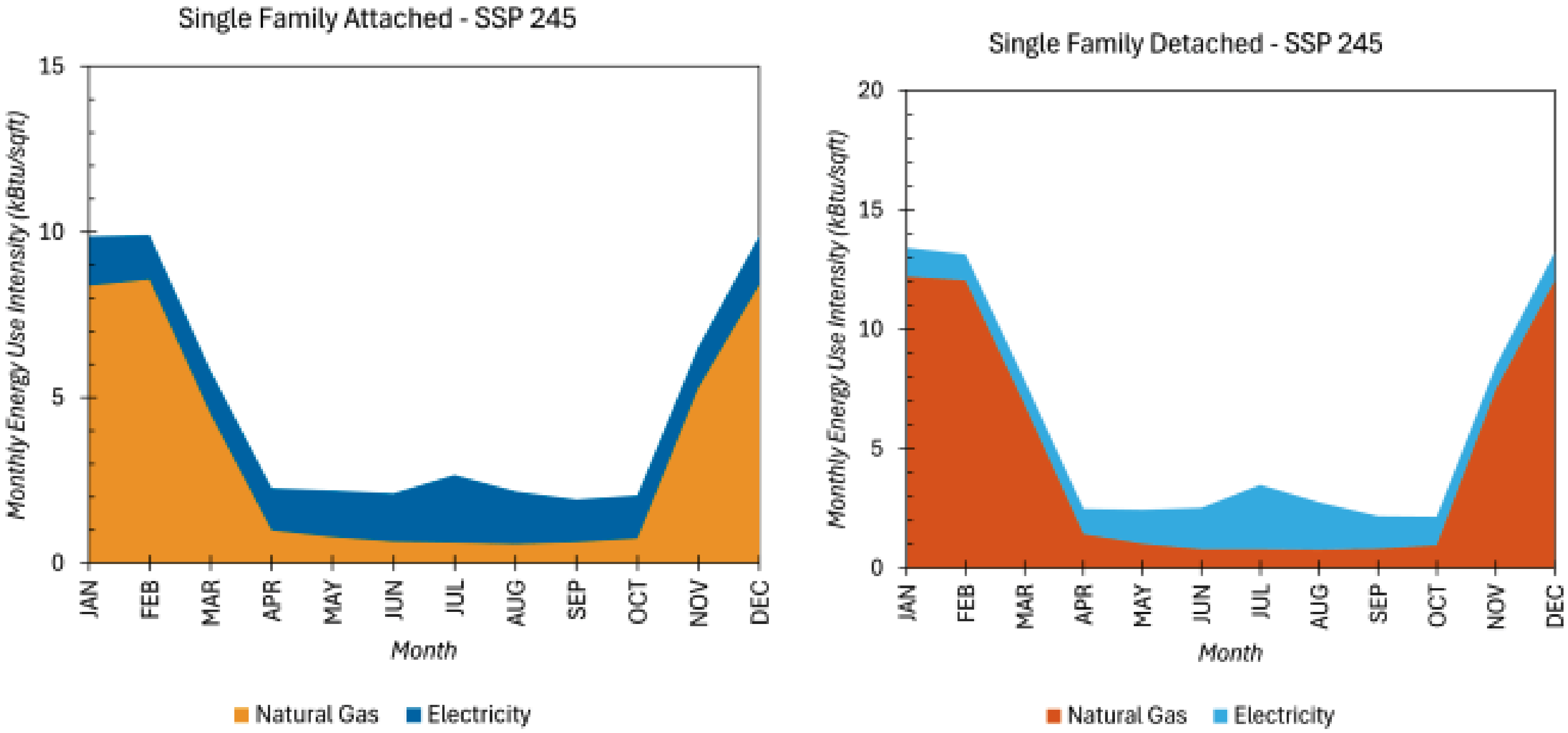


Figure 5.3: Modeled monthly space conditioning loads by energy source for single family attached and single family detached homes in the Metro Area under climate scenario SSP 245.

Building Energy Design Scenarios

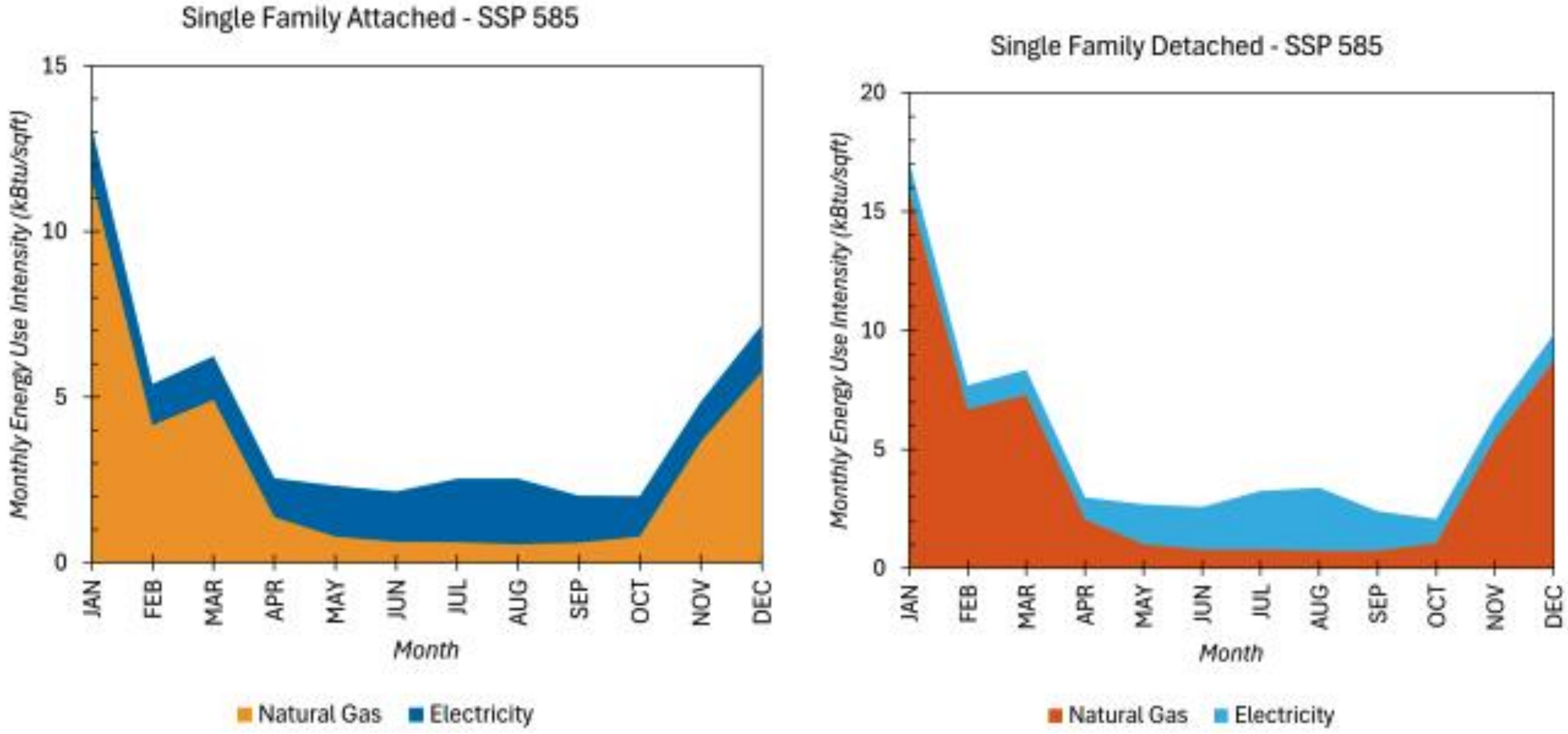


Figure 5.4: Modeled monthly space conditioning loads by energy source for single family attached and single family detached homes in the Metro Area under climate scenario SSP 585.

Building Energy Design Scenarios

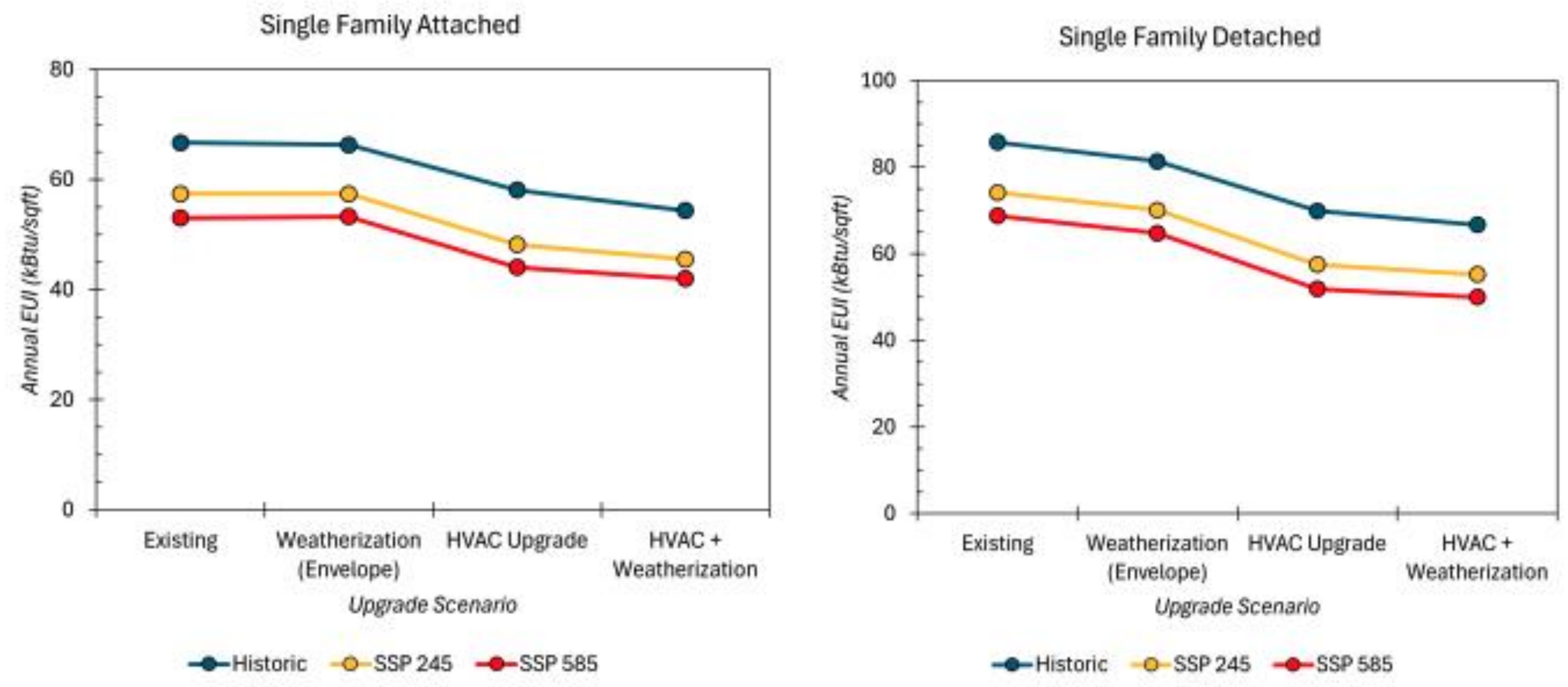
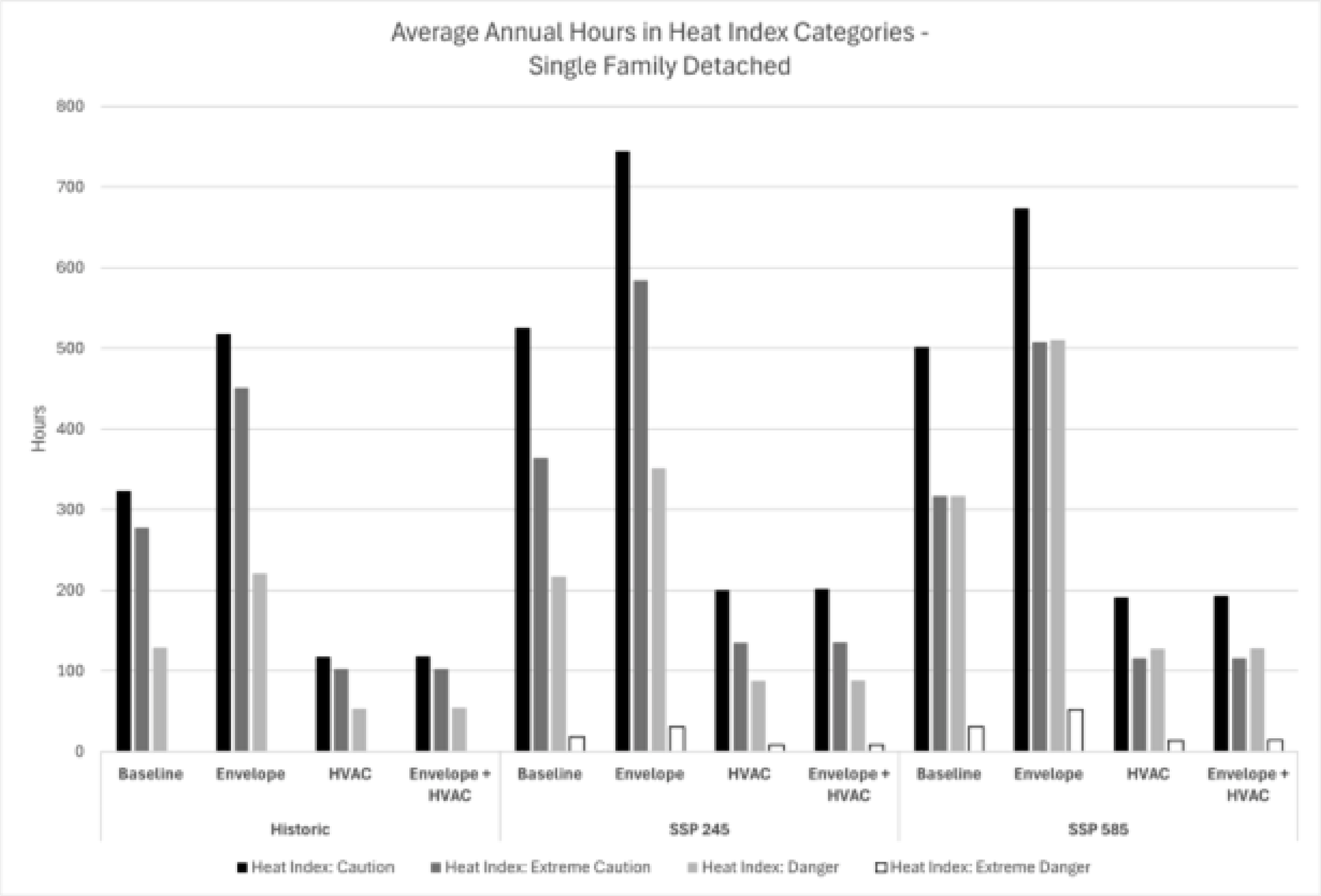
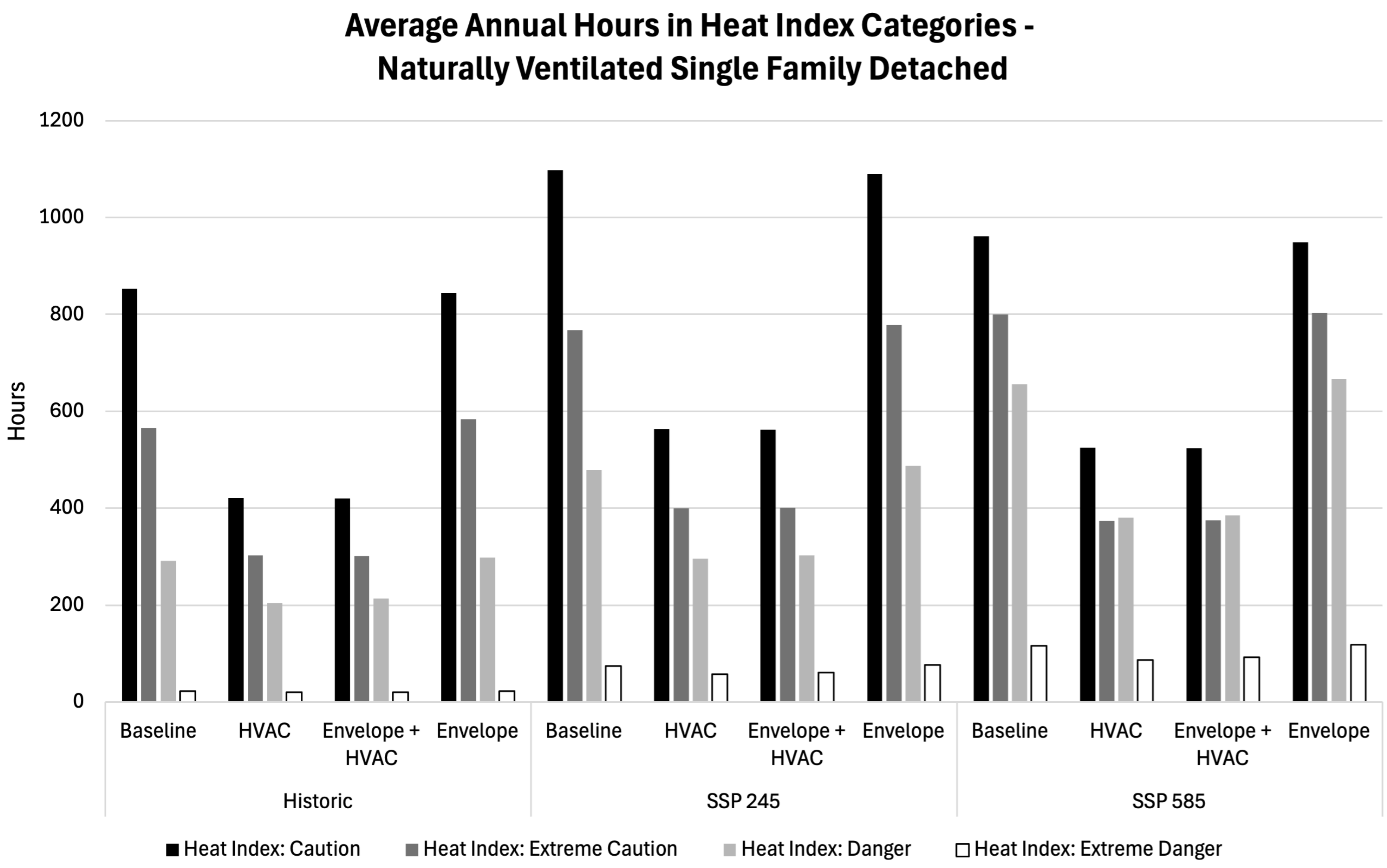


Figure 5.5: Modeled annual energy demand for single family attached and single family detached homes in the Metro Area for baseline and improved performance, in historic and future climate scenarios.

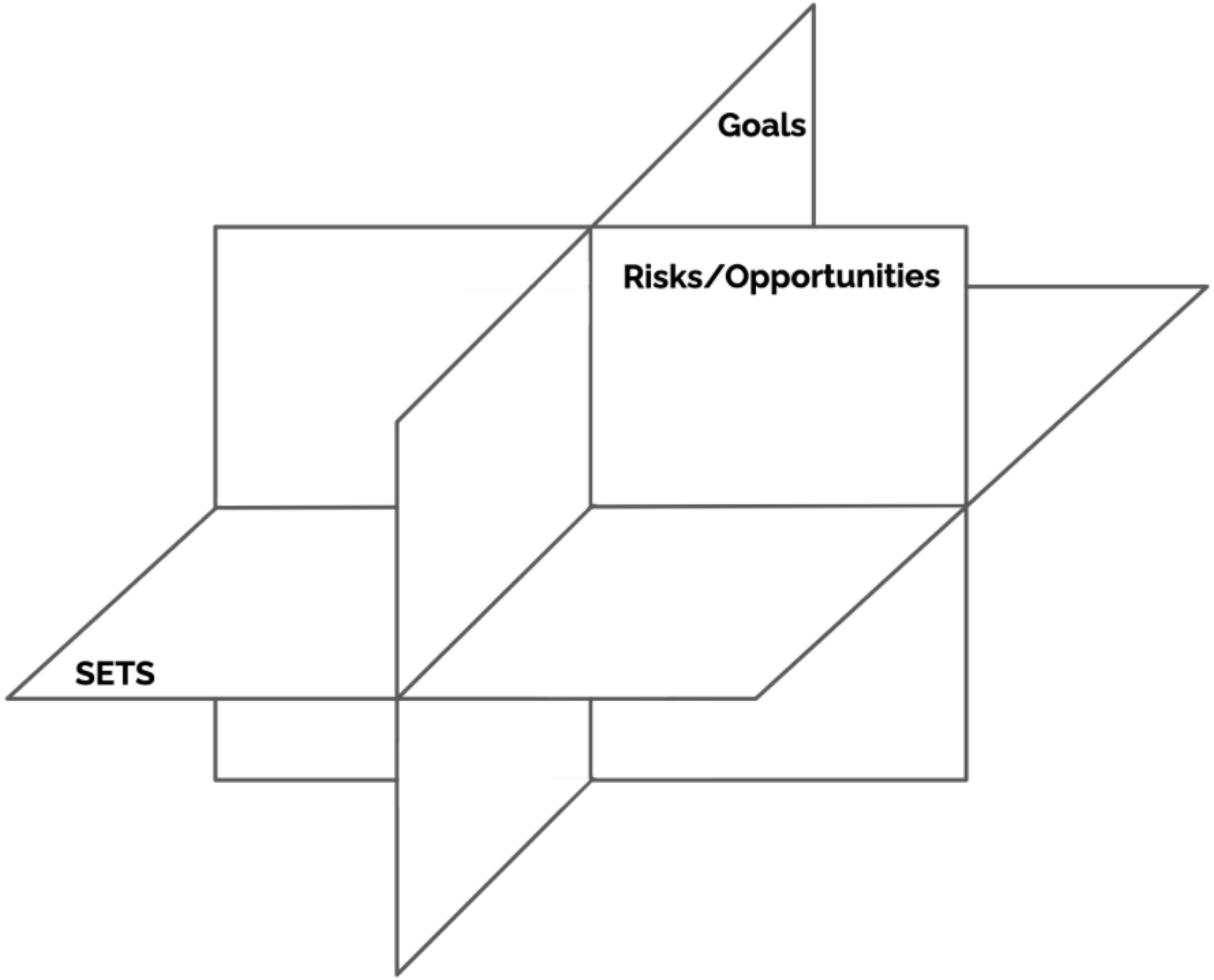
Building Energy Design Scenarios



Building Energy Design Scenarios

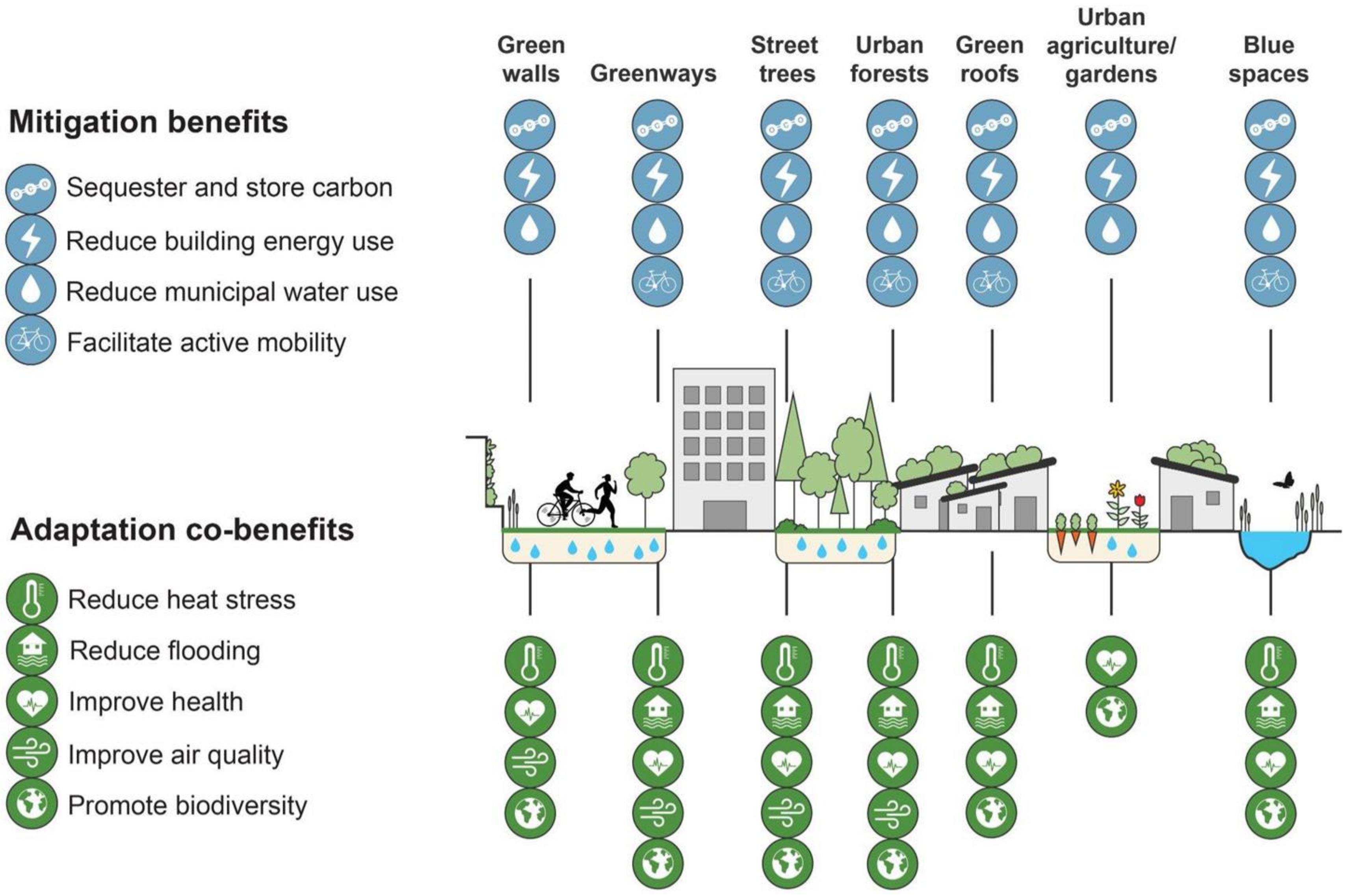


Map the relationship of the infrastructure SETS, goals and risk



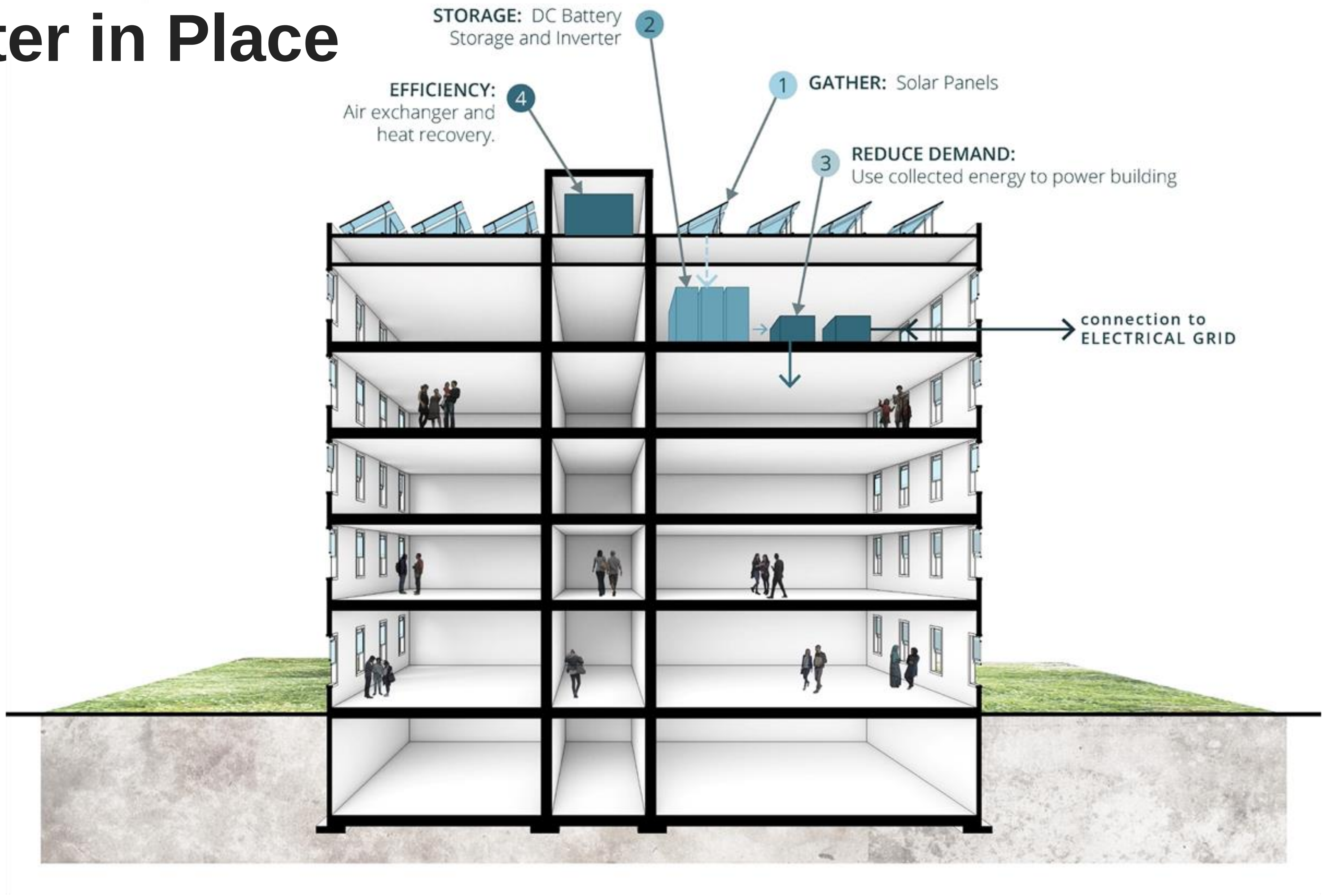
A Whole Community Approach

- Not just the physical structure but the social systems, capacity and cohesion it is necessary to create
- Resilience hubs / resilience communities



TNC, 2023;NCA5, 2023

Shelter in Place



Shelter in Place

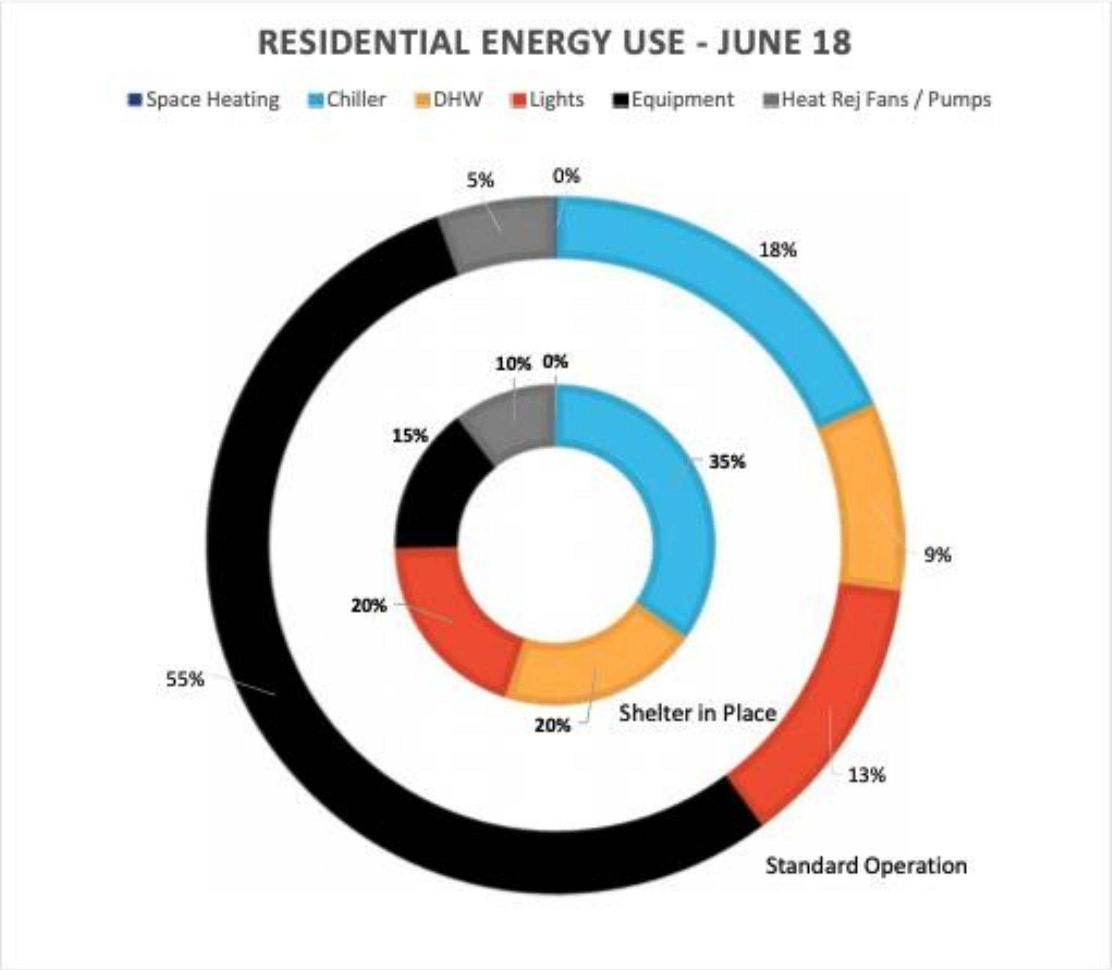


Figure 22: Multi-Family Residential Energy Use By Type, Standard and Shelter in Place Modes

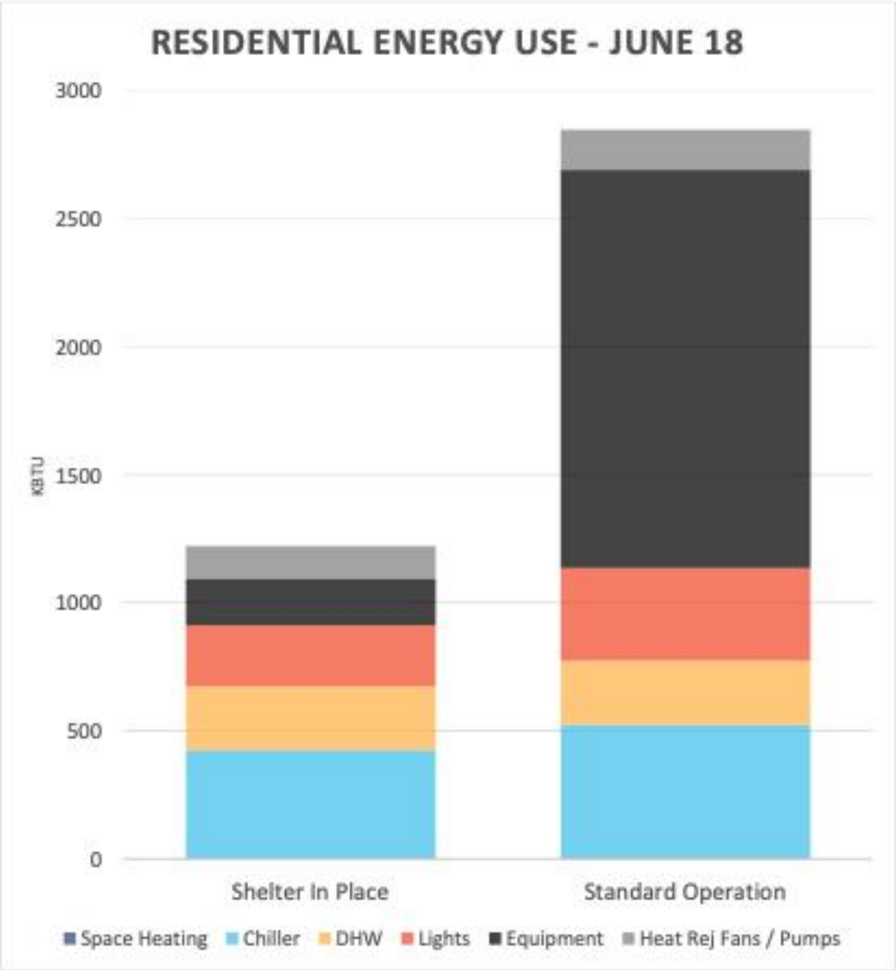


Figure 23: Multi-Family Residential Energy Use By Type, Standard and Shelter in Place Modes

Shelter in Place

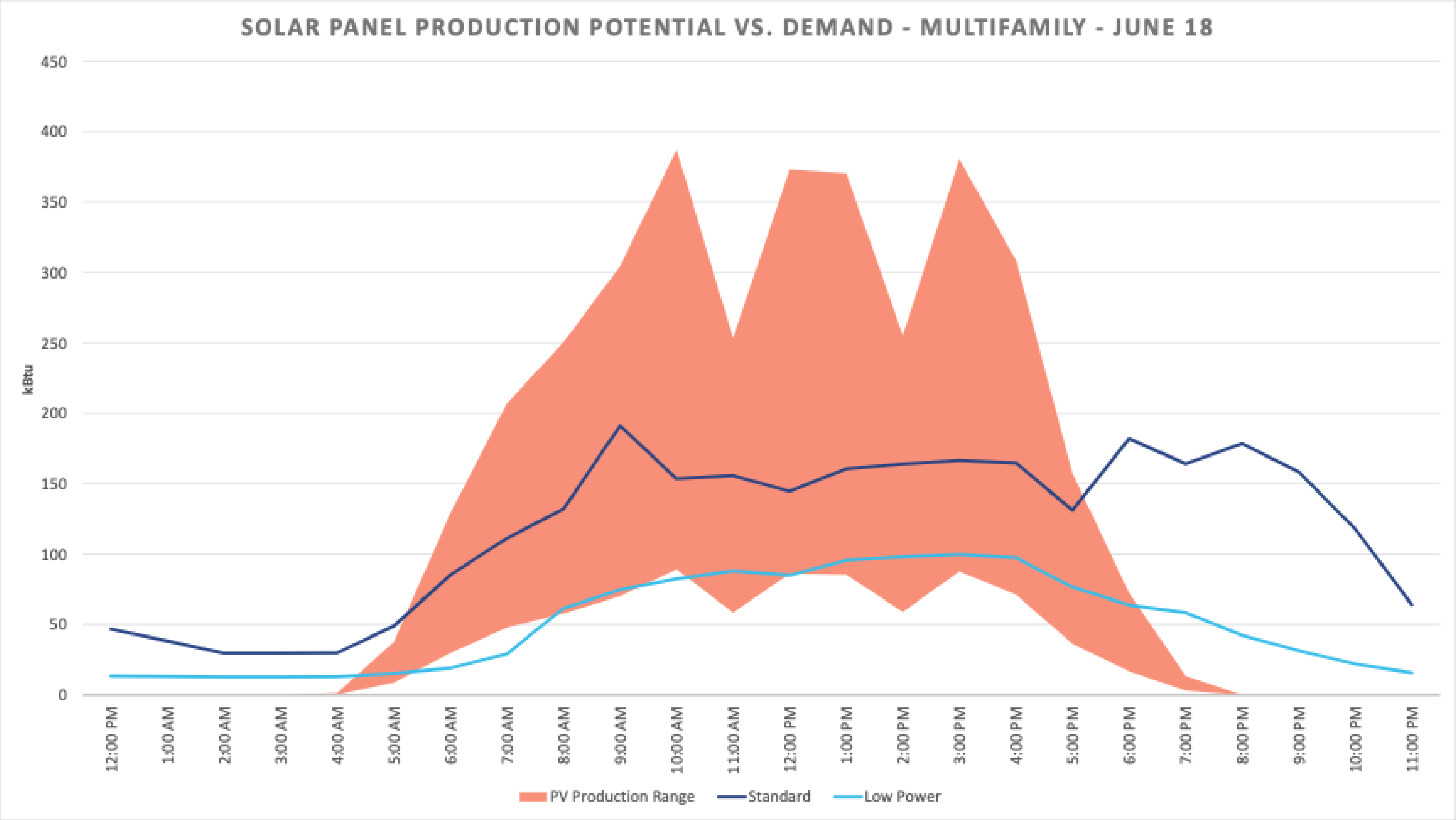
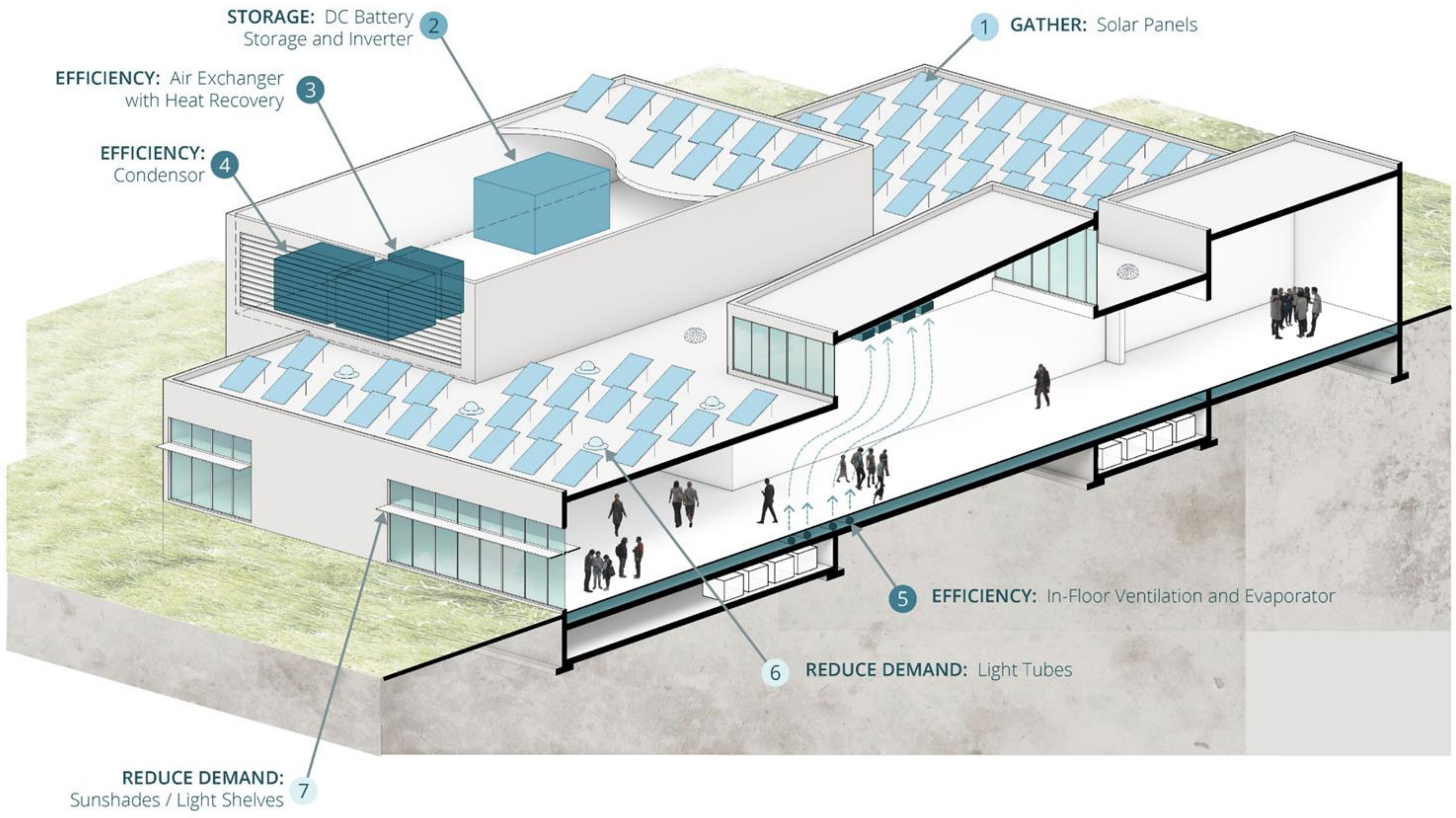


Figure 24: Multi-Family Residential PV Production and Energy Use

Resilience Hubs



Resilience Hubs

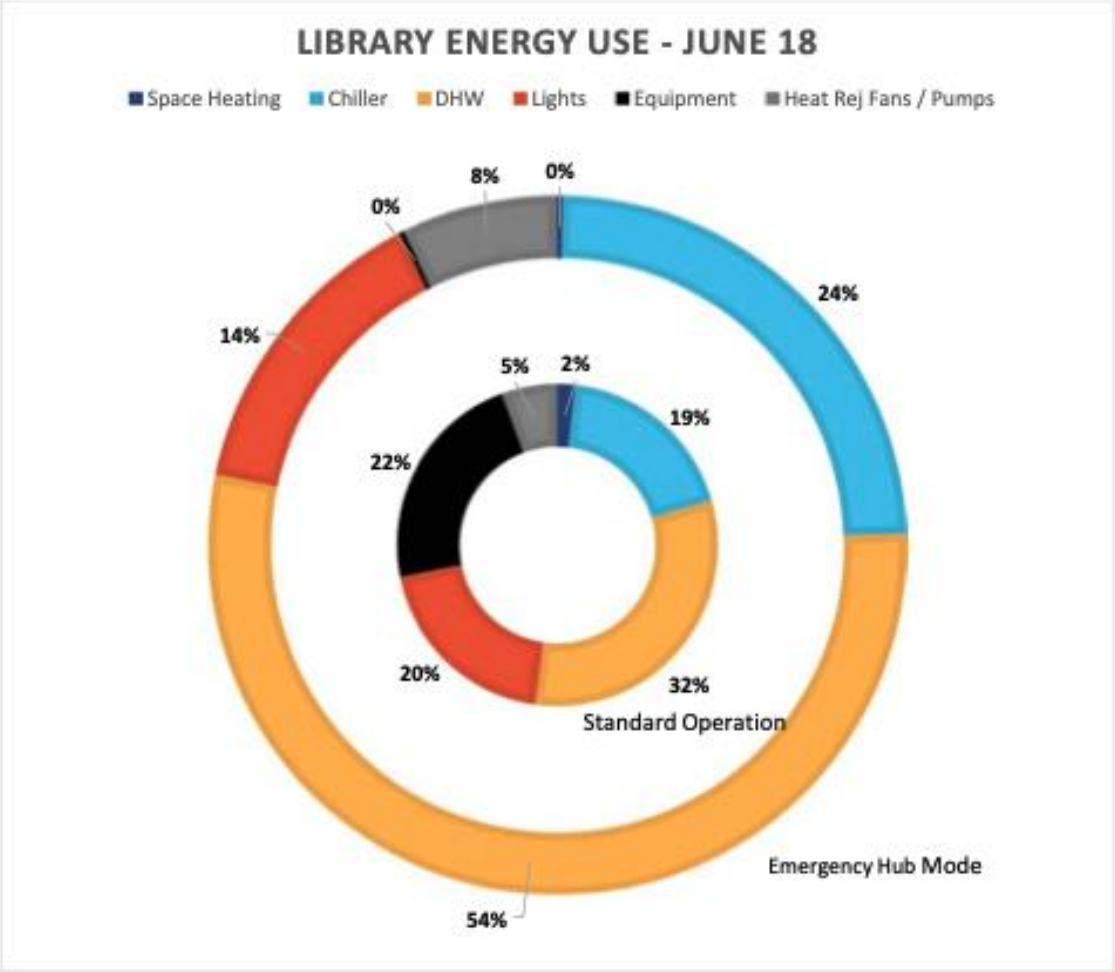


Figure 31: Library Energy Use By Type, Standard and Emergency Hub Modes

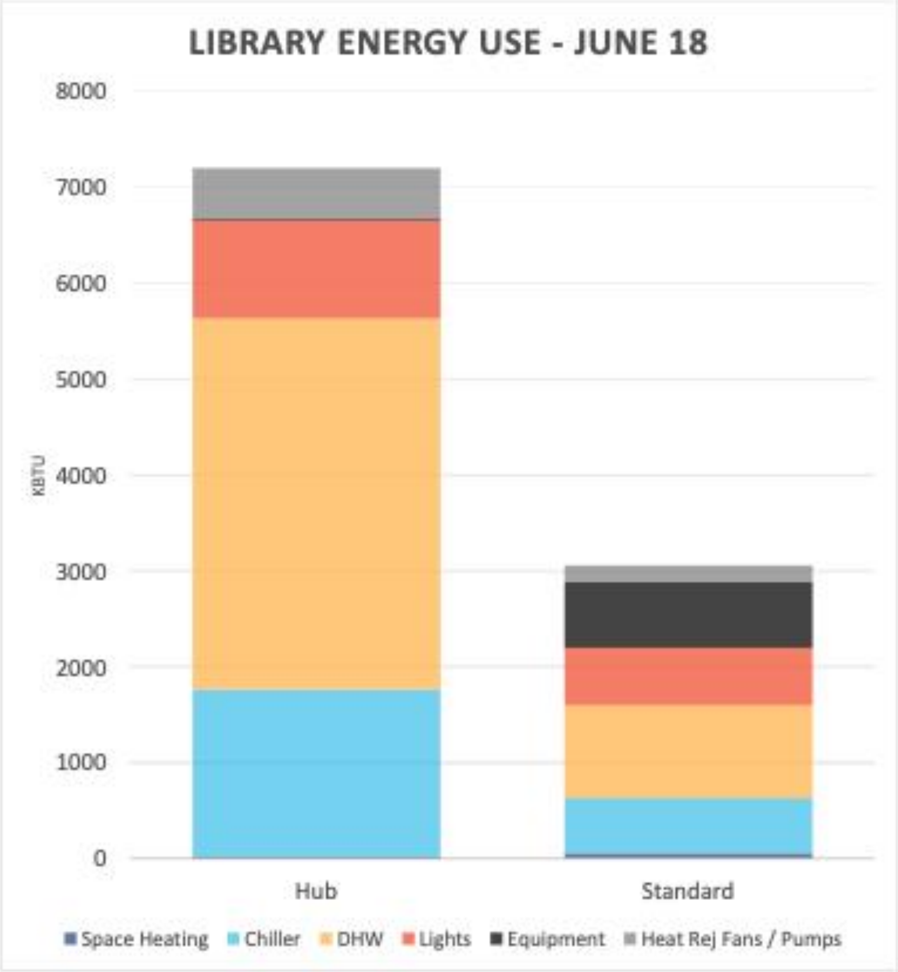


Figure 32: Library Energy Use By Type, Standard and Emergency Hub Modes

Resilience Hubs

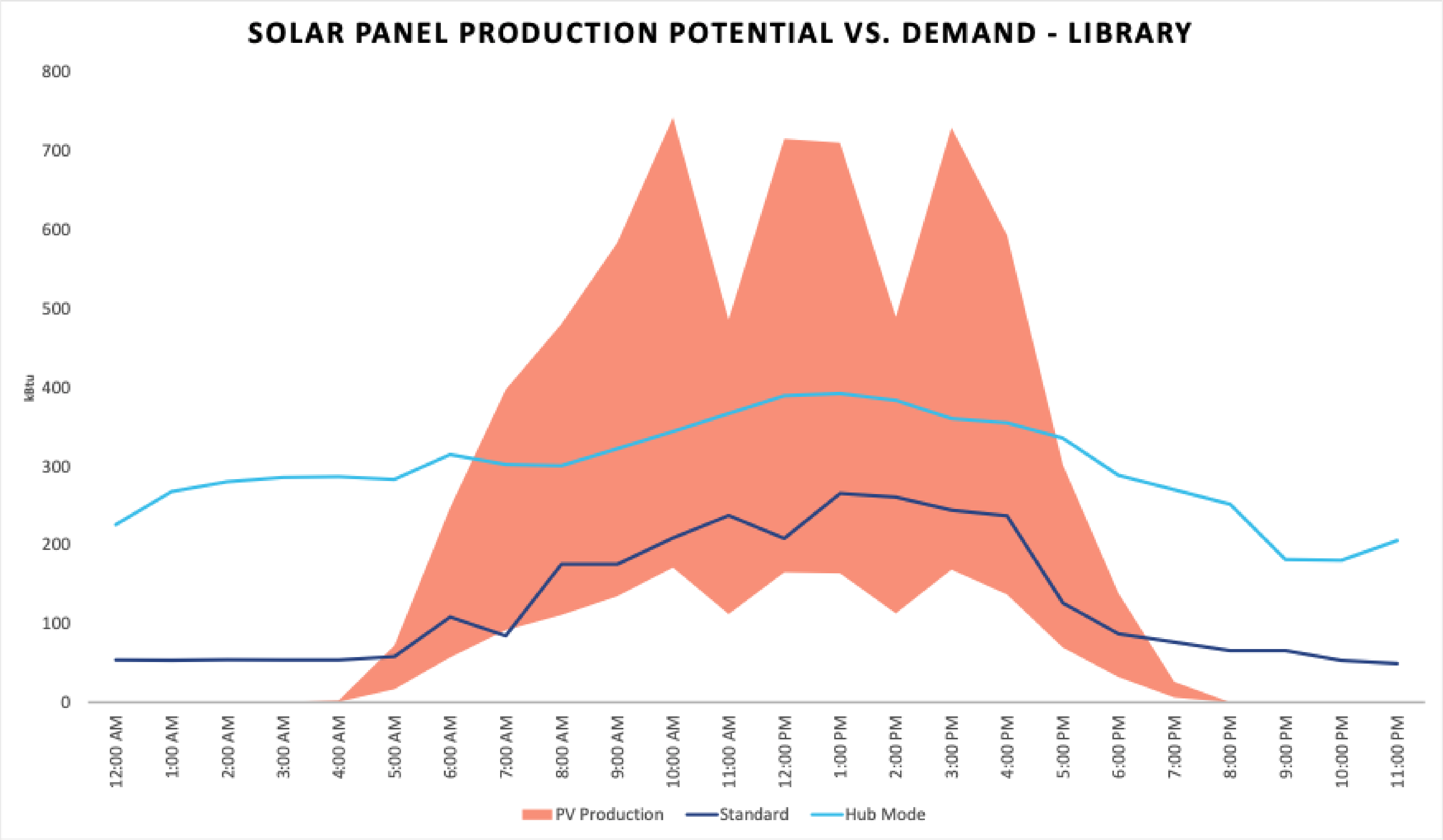


Figure 33: Library PV Production and Energy Use

Resilience Hubs

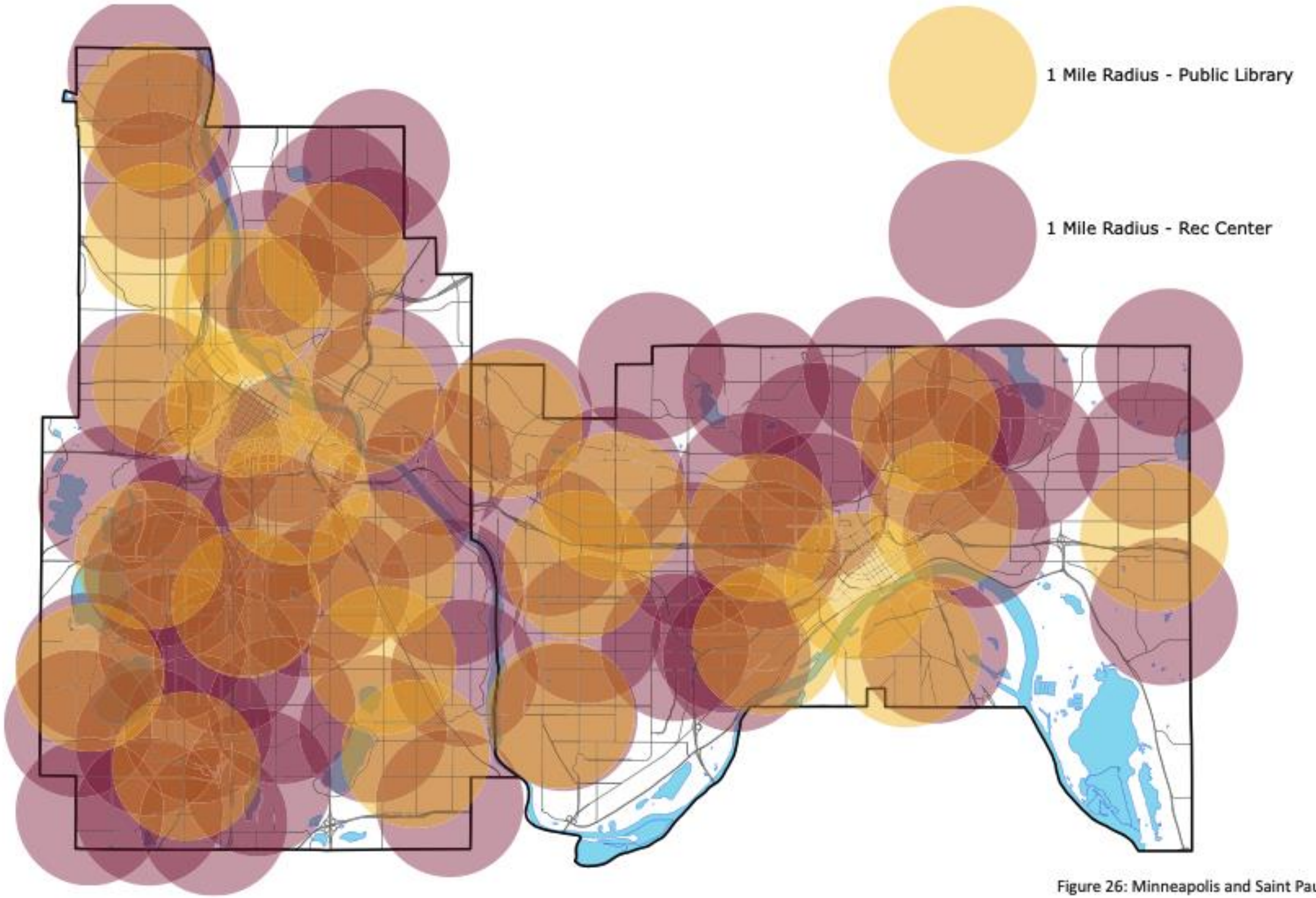


Figure 26: Minneapolis and Saint Paul Community Hubs

Resilience Adaptation of Sustainable Buildings

Resilience Hubs

Figure 27: Example Hub Catchment Area

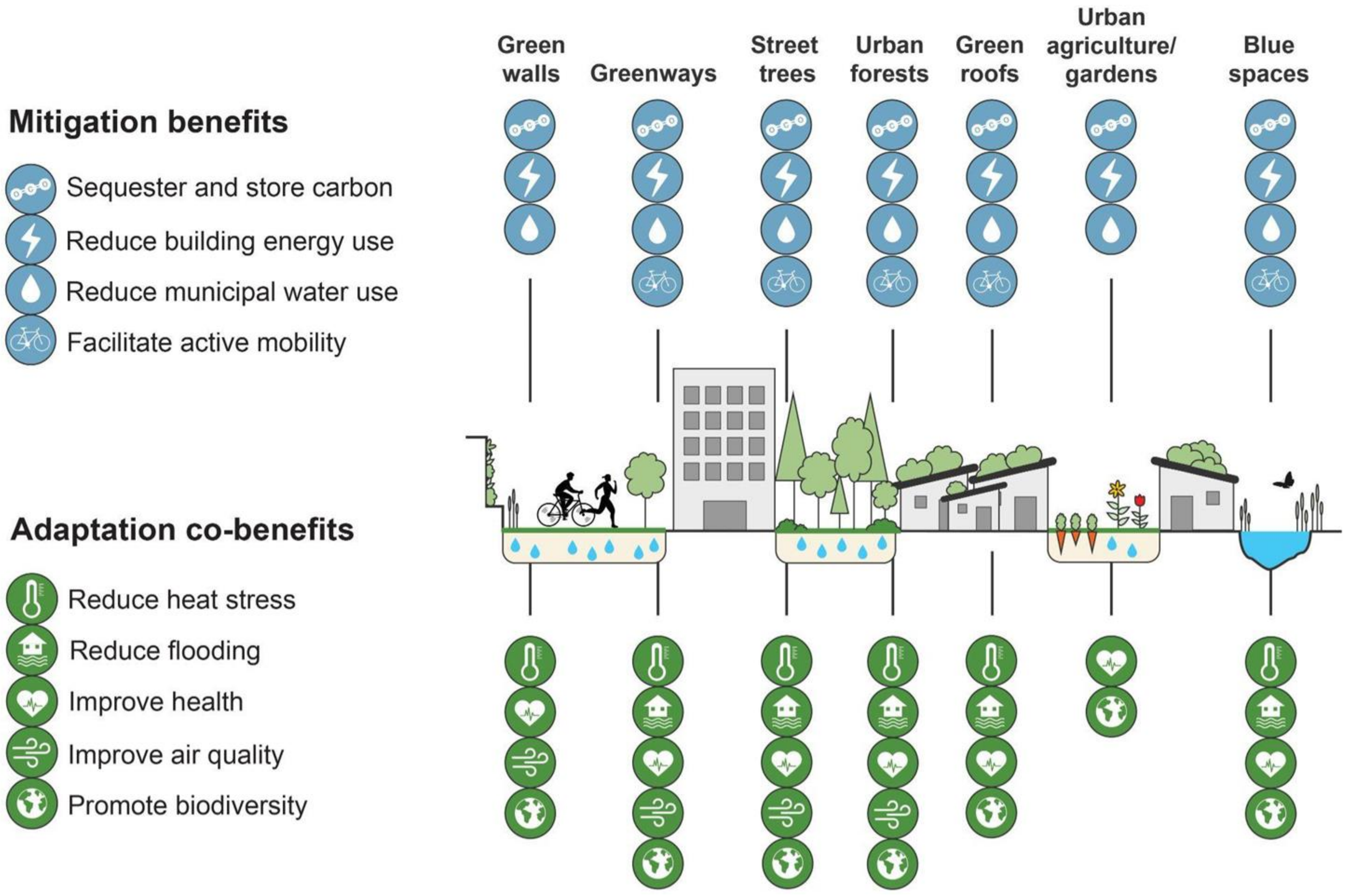
Average Number of Residents within 1/2 mile radius of library
Saint Paul - 4,567 people
Minneapolis - 6,013 people

The library prototype can support roughly 550 people in emergency disaster hub mode, approximately 10% of the population living within 1/2 mile in an average urban neighborhood.

Statistically, the supported population will include approximately:
64 people with a disability
125 people living within 150% of the poverty line
42 children under the age of 5
52 people over the age of 65

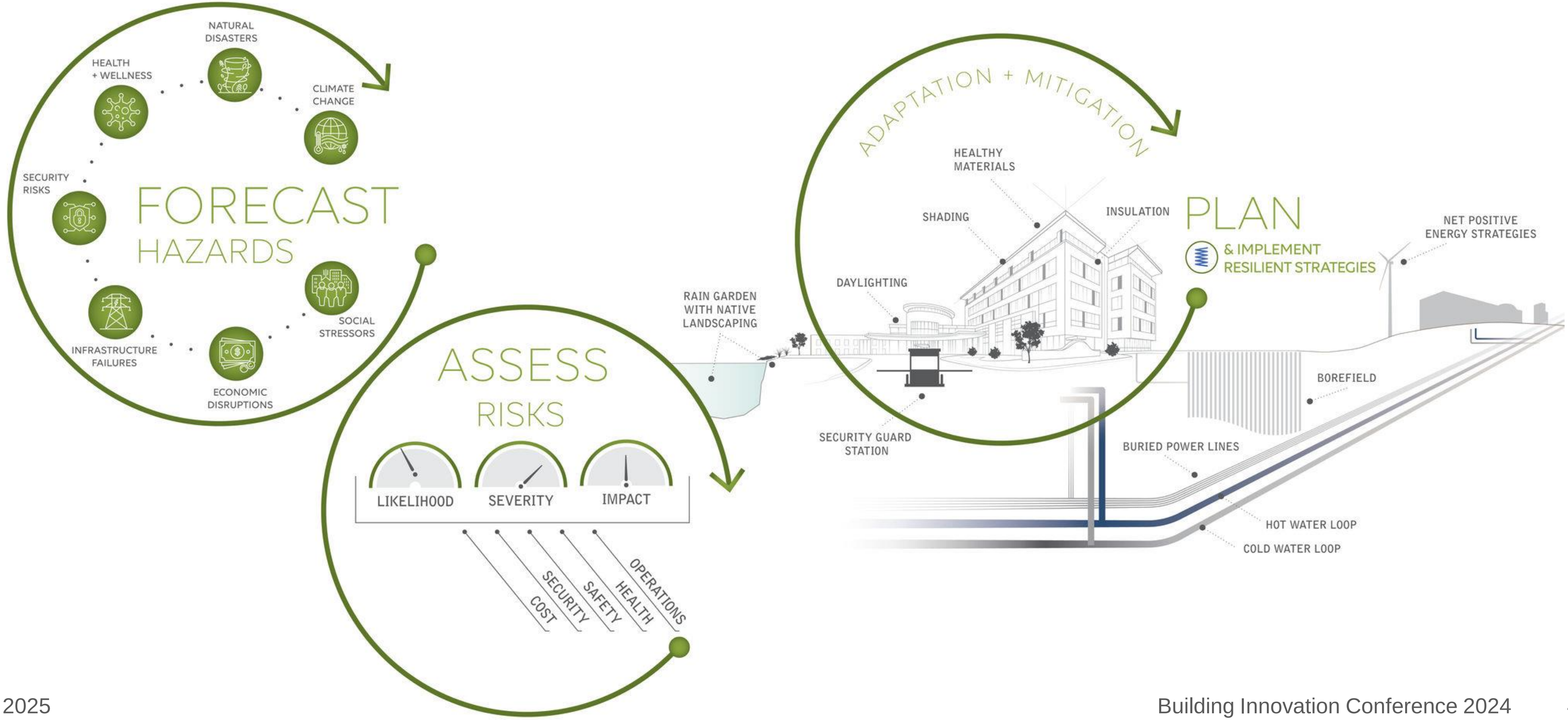
A Whole Community Approach

- Not just the physical structure but the social systems, capacity and cohesion it is necessary to create
- Resilience hubs / resilience communities



TNC, 2023;NCA5, 2023

Planning for Resilience



East Coast Case Study

Cell Signaling Technology Master Plan

Restoration of a granite quarry in Manchester-by-the-Sea, Massachusetts

Phased construction

Climate Resilience Design Standards Tool
ResilientMass Action Team

Project Search

Project Name

cell signaling

Advanced Query

Clear Search | Search

1 Result: New Project

Cell Signaling Technology
PrivateOther

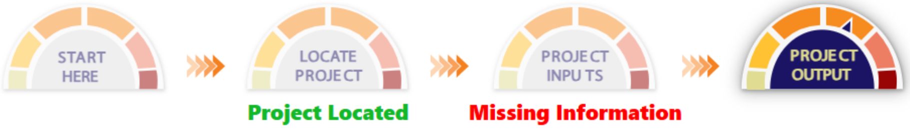
Created By: ArianeLaxo — Project #23914
Towns: Manchester — Assets: 1

Cell Signaling Technology

Project Number: 23914 (Link)
Project Status: Not Scored

Tool Reporting Workflow

Hello, ArianeLaxo
Terms of Use
Delete Project



Overall Project Scores Output

The Ecosystem Service Benefits Score and Preliminary Climate Hazard Exposure Ratings presented below are assigned to the overall project, while the Preliminary Climate Risk Ratings and Climate Resilience Design Standards are asset-specific. The Scores and Standards are based on the questions previously answered and the location of the overall project. This information can be used to think critically about site suitability, regional resilience efforts, and adaptive site design for long-term climate resilience.

Environmental Justice

In Massachusetts, an Environmental Justice (EJ) neighborhood (census block group) is defined as meeting one or more criteria linked to the size of a census block group's minority populations, median household income, and language isolation. EJ neighborhoods typically include climate vulnerable populations, who

Does this project fall within mapped Environmental Justice neighborhoods? No

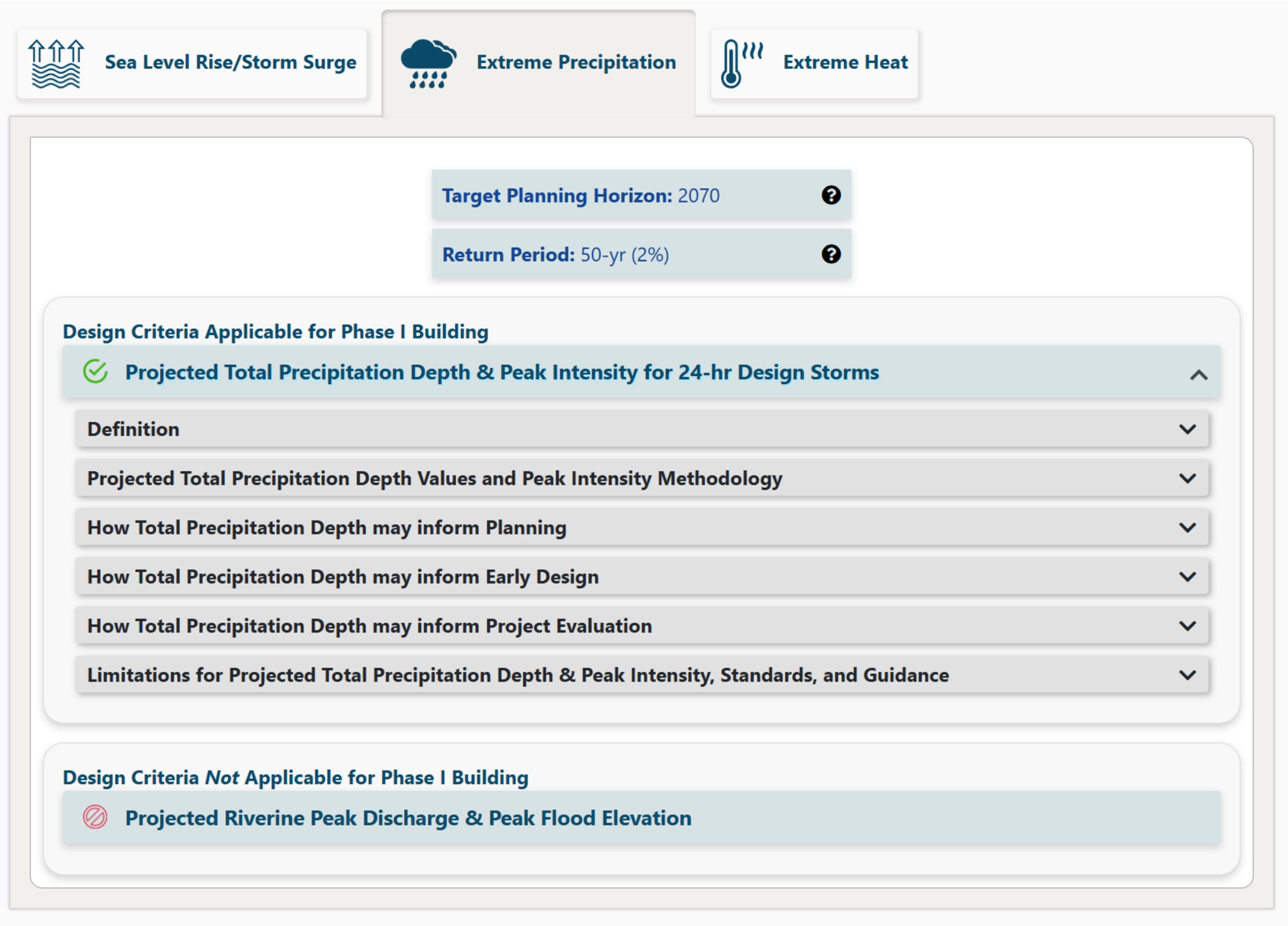
Ecosystem Benefits

The purpose of this output is to provide an overall indication of the Ecosystem Service Benefits (ESB) provided by a project, through protection of natural resources and implementation of nature-based solutions. Natural systems and ecosystem services provide great economic value and social benefit, often untapped in non-resilient

Ecosystem Benefits Scores High

Preliminary Climate Hazard Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. Click on the question mark to identify why your project location is


Sea Level Rise/Storm Surge
Extreme Precipitation
Extreme Heat
Target Planning Horizon: 2070
Return Period: 50-yr (2%)
Design Criteria Applicable for Phase I Building
Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms
Definition
Projected Total Precipitation Depth Values and Peak Intensity Methodology
How Total Precipitation Depth may inform Planning
How Total Precipitation Depth may inform Early Design
How Total Precipitation Depth may inform Project Evaluation
Limitations for Projected Total Precipitation Depth & Peak Intensity, Standards, and Guidance
Design Criteria Not Applicable for Phase I Building
Projected Riverine Peak Discharge & Peak Flood Elevation

Sea Level Rise/Storm Surge | Extreme Precipitation | Extreme Heat

Target Planning Horizon: 2070

Percentile: 90th Percentile

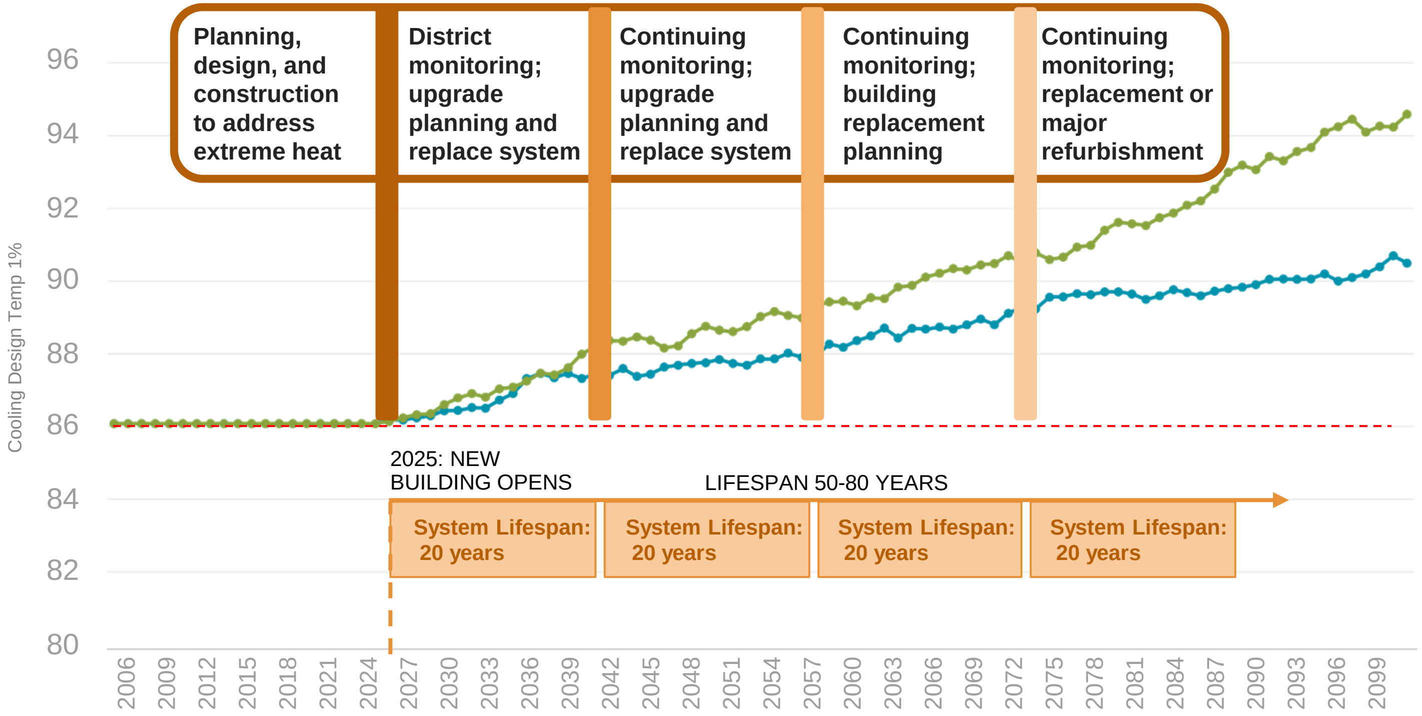
Design Criteria Applicable for Phase I Building

- Projected Annual/Summer/Winter Average Temperatures
- Projected Heat Index
- Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F
- Projected Number of Heat Waves Per Year & Average Heat Wave Duration
- Projected Cooling Degree Days & Heating Degree Days (base = 65°F)

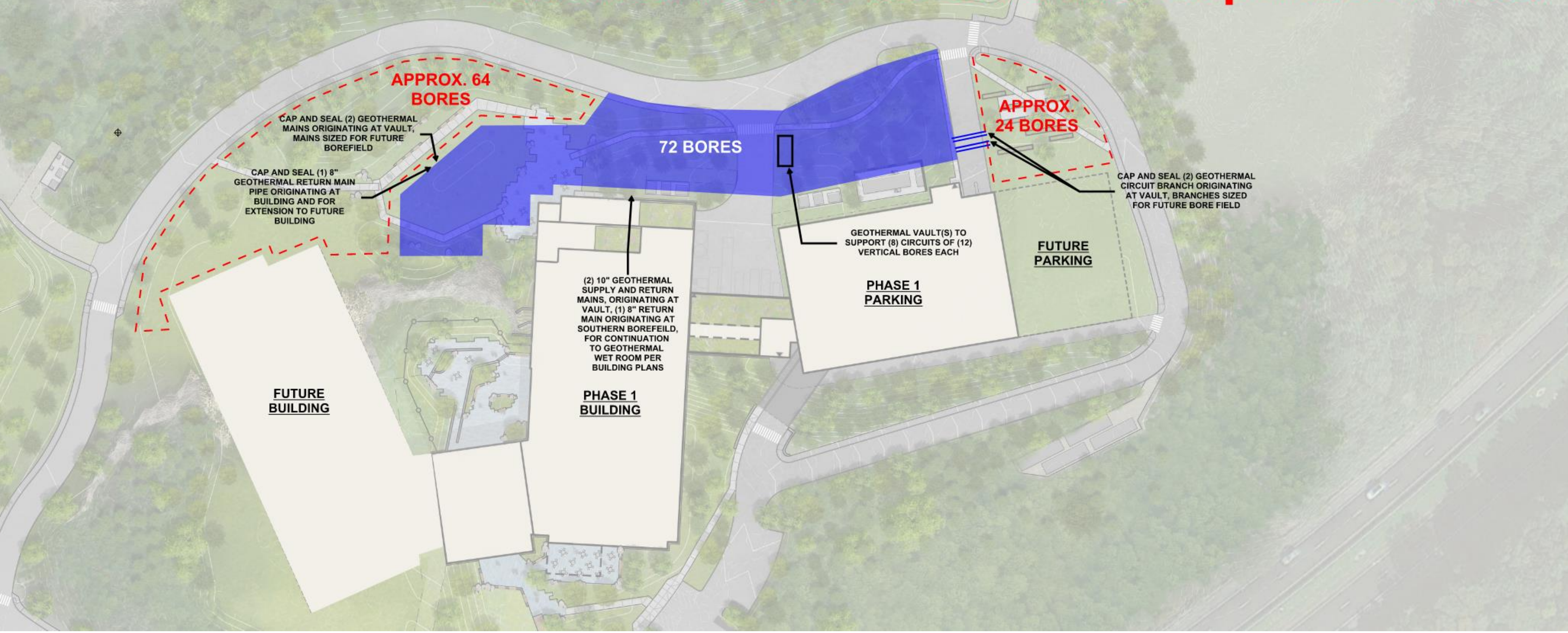
Design Criteria *Not* Applicable for Phase I Building

- Projected Growing Degree Days

Critical Decision Points for Extreme Heat

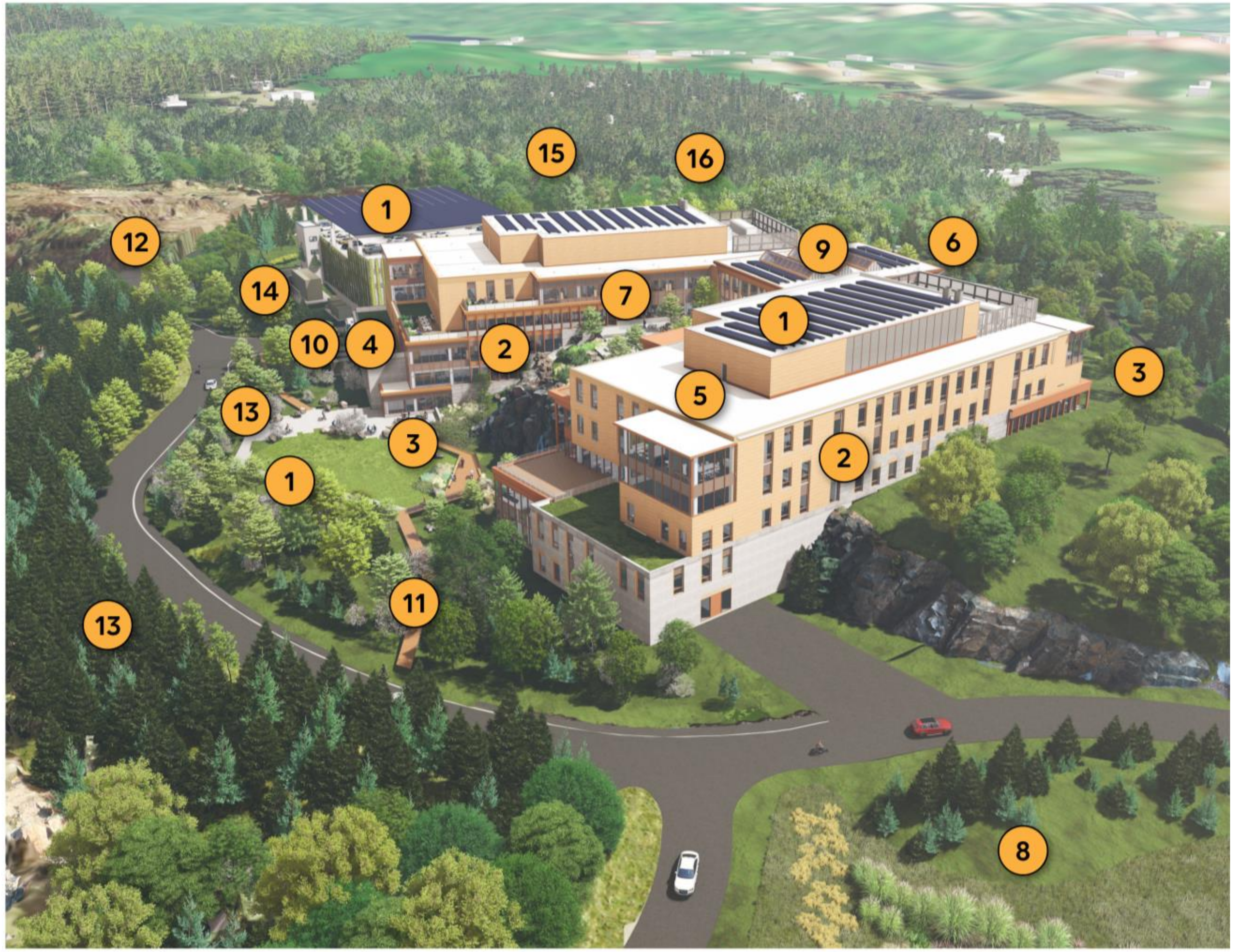


Phase 1 Geothermal Area
Planned Future Geothermal Expansion Area



Co-benefits of sustainability & resilience

1. On-site renewable energy
2. Envelope designed to maximize natural light and minimize heat gain
3. Indoor / outdoor connections
4. Biophilic design strategies throughout to connect humans to nature
5. High SRI roof to minimize heat absorption
6. Bird safe glass
7. Access to daylight & views for improved well-being, with daylight sensors for energy use reduction
8. Stormwater management & rain gardens sized for future climate change projections
9. Mass timber lobby structure for lower carbon
10. Healthier Materials & Indoor air quality monitoring
11. Campus accessibility, walkability & wayfinding
12. Public parking & trailhead connection to Monoliths
13. Native plantings and ecological services restoration
14. Rainwater/greywater collection for site irrigation
15. Battery storage
16. Building load reduction and electrification strategies



West Coast Case Study

San Francisco Bay Area

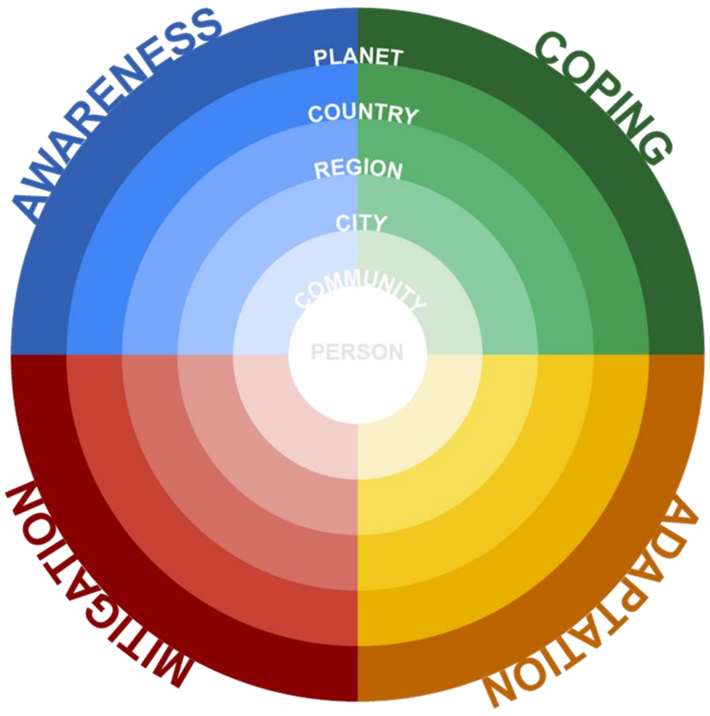
Approaching Resilience

Awareness: Engage stakeholders and establish ongoing assessments to raise understanding of climate and other hazards, laying the groundwork for informed decision-making.

Coping: Provide immediate resources and strategies to individuals and organizations to manage current exposures and sensitivities to climate risks.

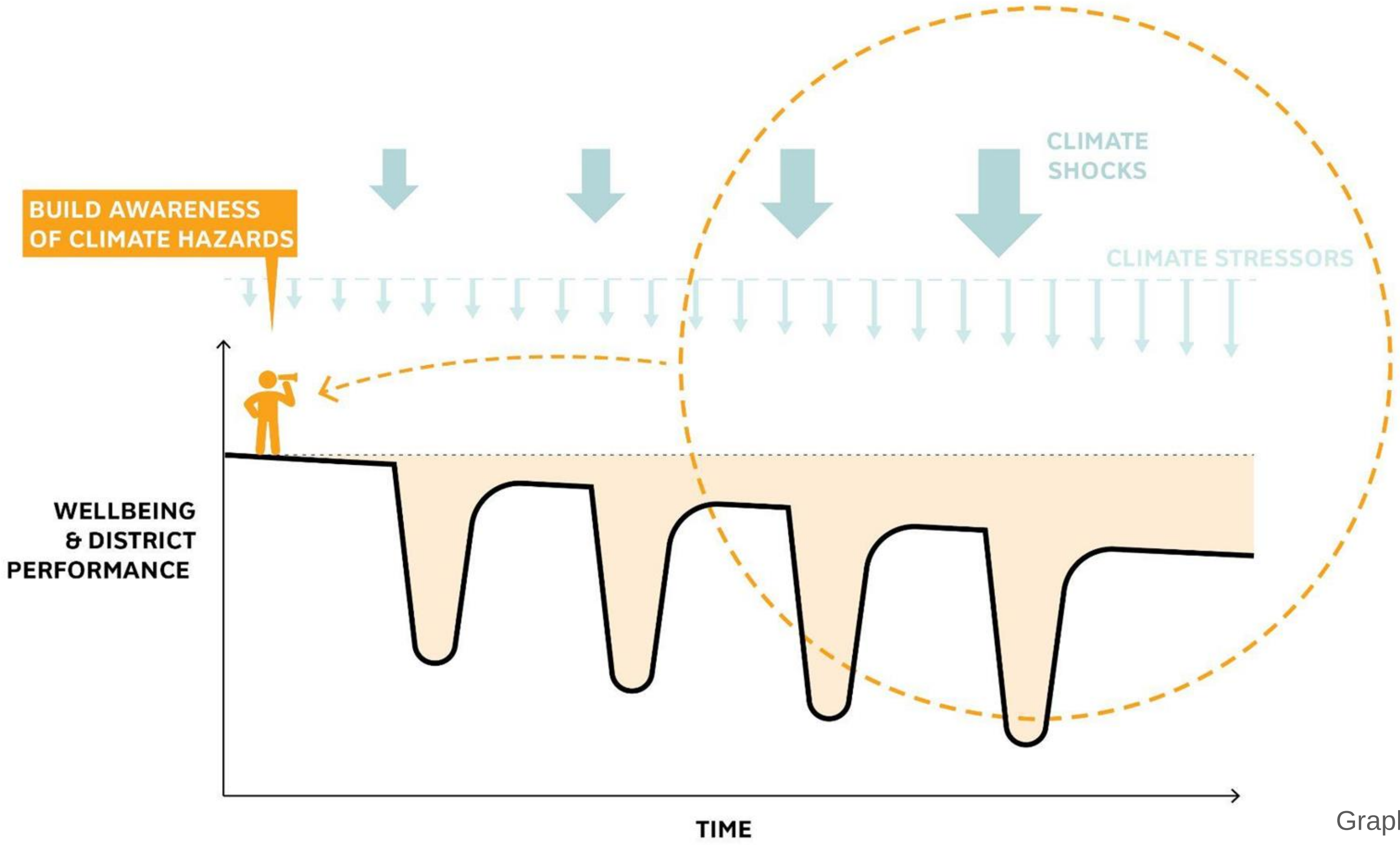
Impact Mitigation: Reduce near- and mid-term impacts of escalating hazards by intercepting risks through targeted interventions based on present vulnerabilities.

Adaptation: Adjust built environments and infrastructure, behaviors, policies, and financial systems to prepare for and respond to evolving climate threats through long-term adaptation pathways



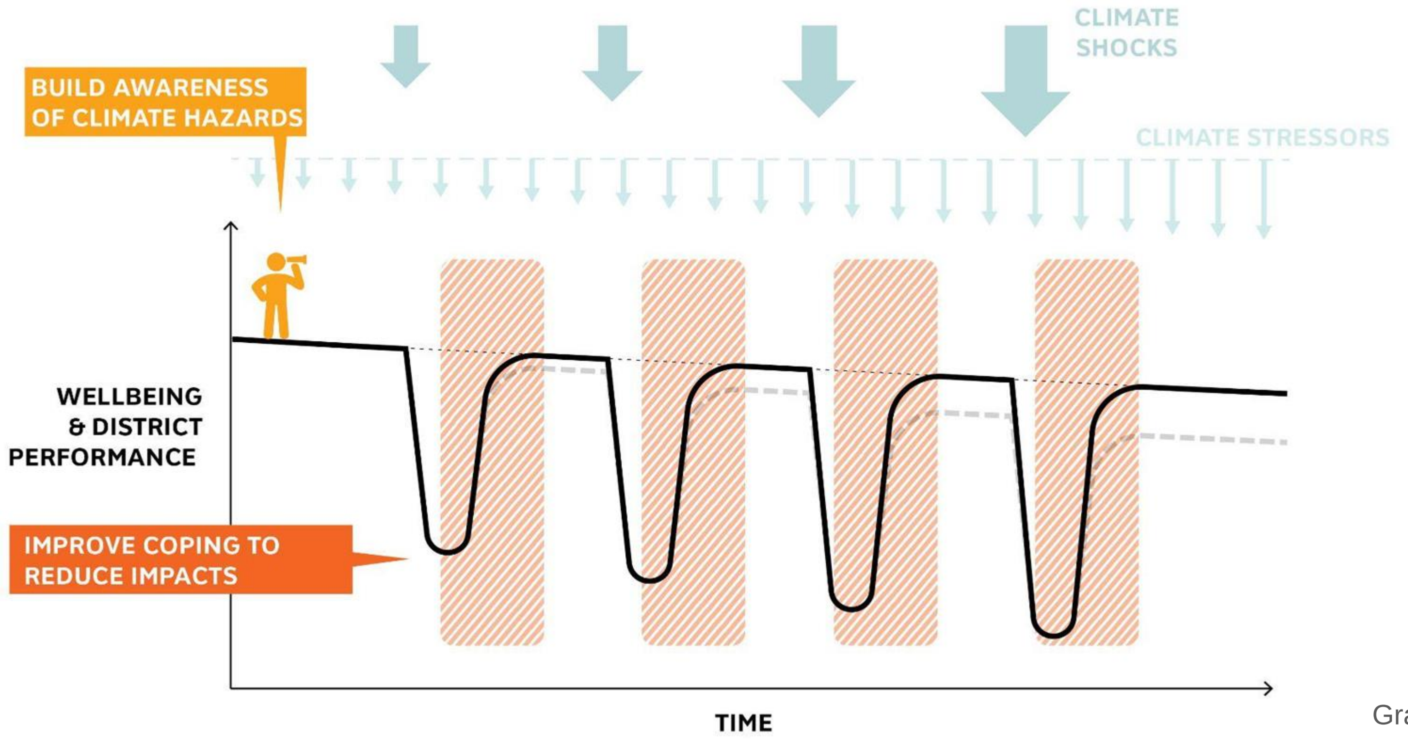
Source: Climate Adaptation Partners

Building Awareness



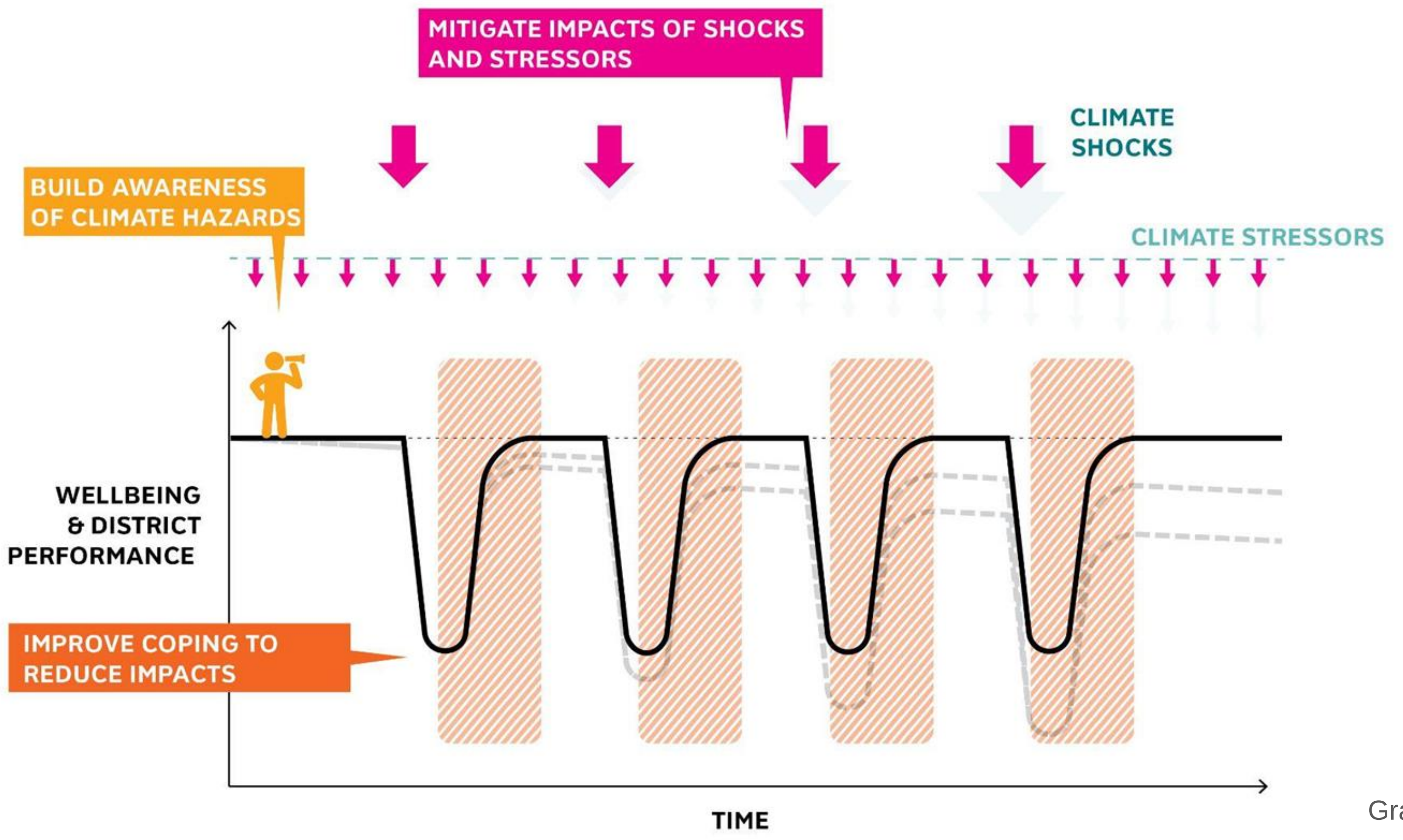
Graphic by: SCAPE

Improving Coping Capacities



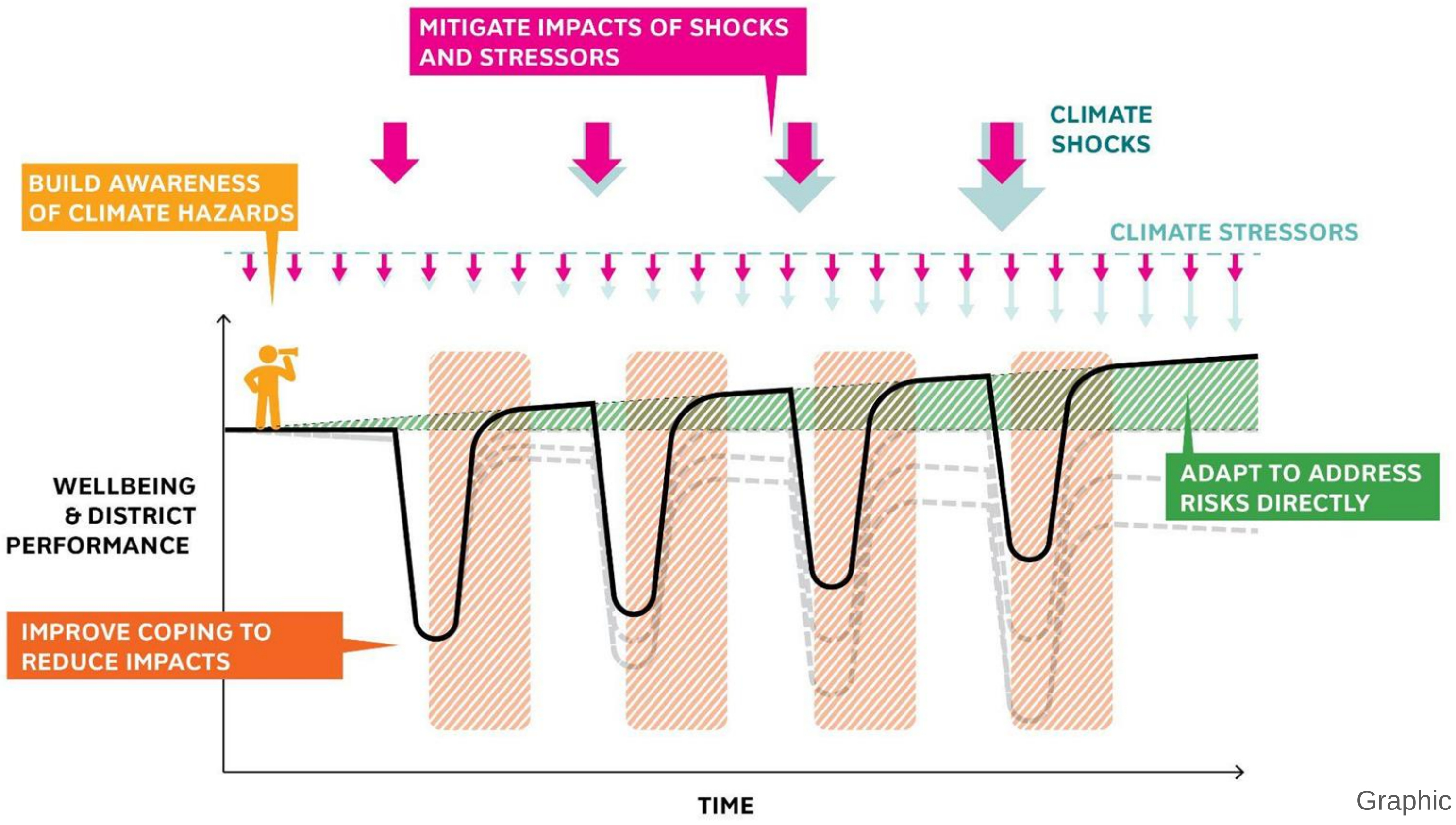
Graphic by: SCAPE

Mitigating Risks



Graphic by: SCAPE

Adapting to Risks



Graphic by: SCAPE

Risk Assessment Guiding Principles

ALL HAZARDS
Acute shocks / chronic stressors that threaten the investment. Hazard intensity,, probability & impact.

RISK ASSESSMENT
Assess risk from hazards based on exposure, sensitivity, and adaptive capacity of assets and nested scales.

ASSETS & REGIONAL SYSTEMS
Physical, social, and infrastructure

Consider “All Hazards”	Taking an **inclusive, all-hazards approach** as a baseline for risk assessment. Not all hazards are uniformly addressed, but decisions should be intentional.
Evaluate Compound and Cascading Consequences	Considering **cascading and compound consequences** of co-occurring hazards.
Understand Implications of Nested Scales	Understanding the **interactions and implications** of the resilience work being planned at the local, state, and federal scales and supporting that work with mutually supportive strategies.
Accommodate for Variation in Risk	Understanding the **range of risk**: through time, through spatial impacts, and in the context of outside dependencies.

Bay Area Climate Hazards

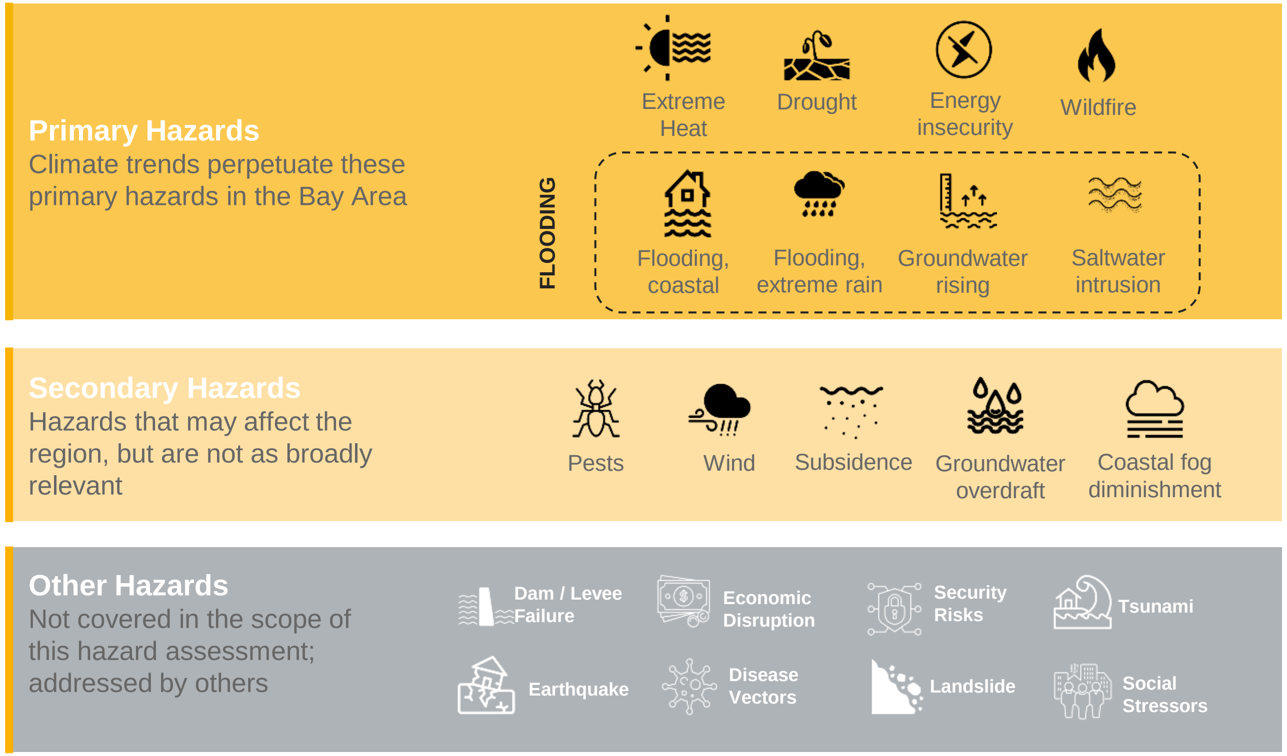
Climate Trends

Rising Temperature

Sea Level Rise

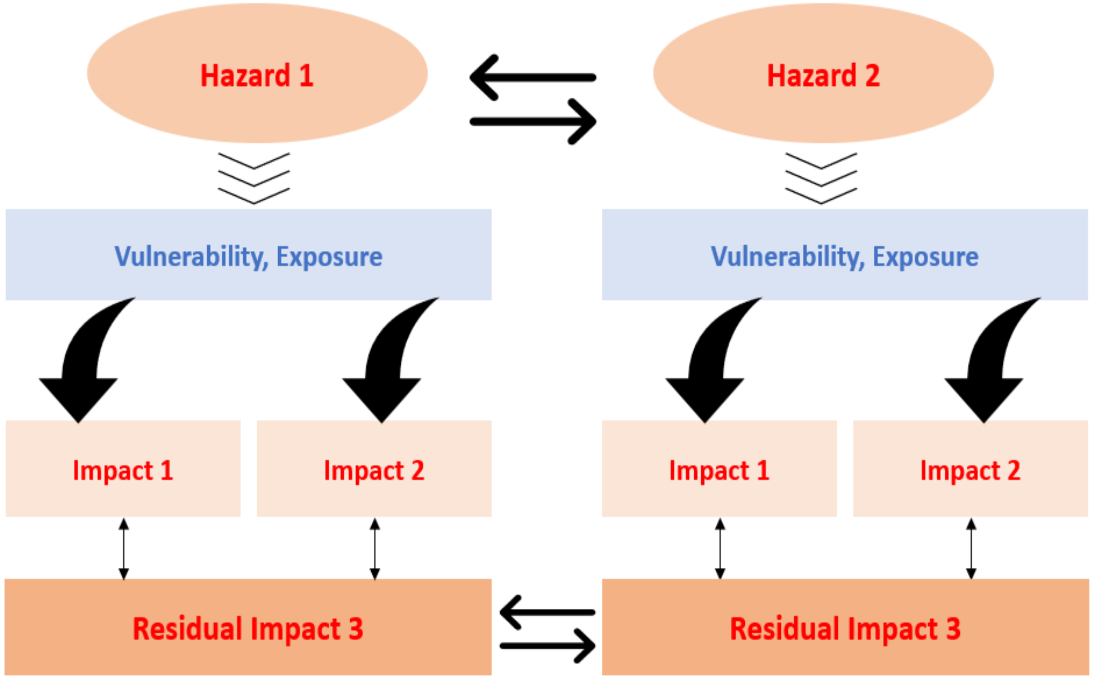
Changes in Precipitation

Climate Hazards

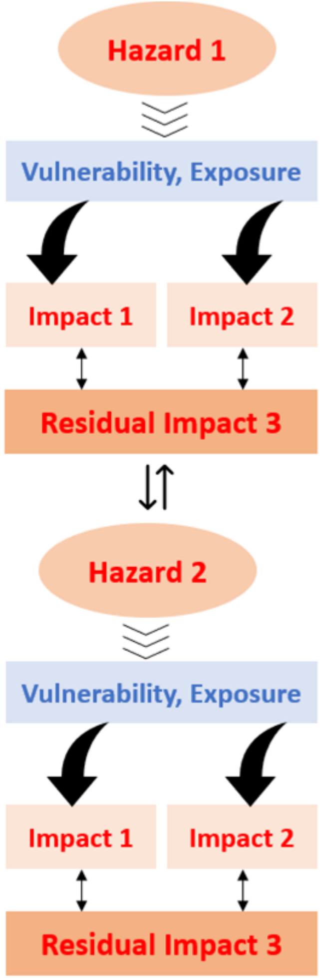


All Hazards Approach

Compounding Hazards: A second hazard that can interact with the first, causing multiplicatively destructive consequences.

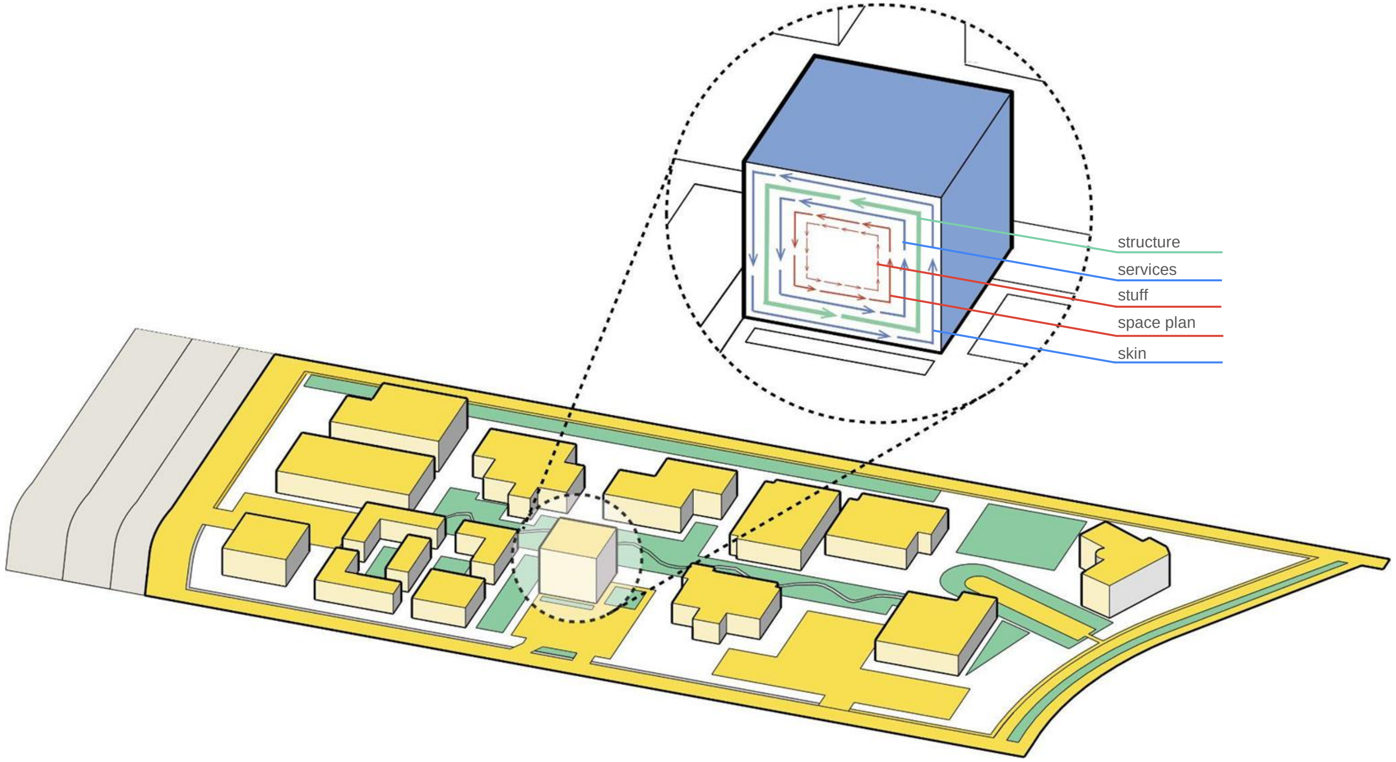


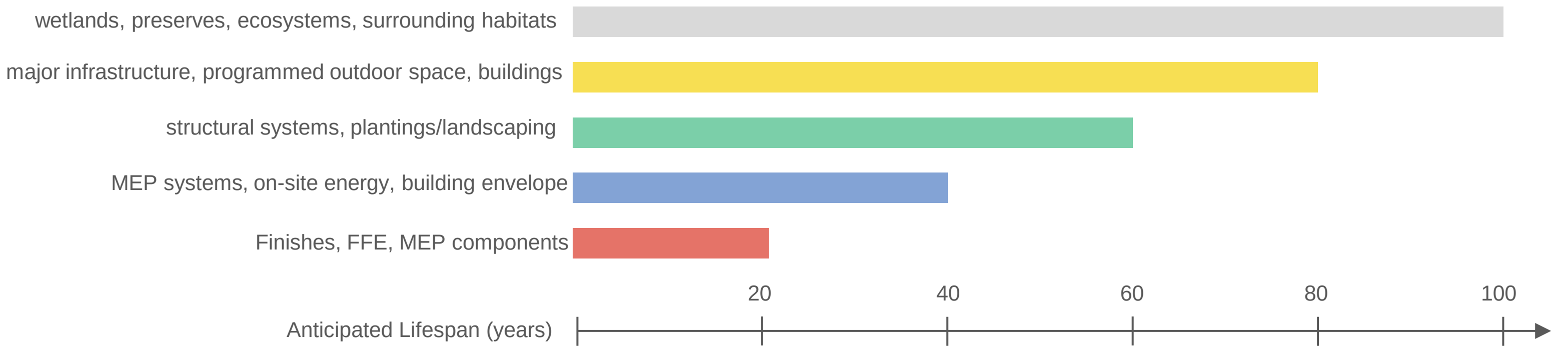
Cascading Hazards: A secondary effect of a primary hazard, tending to increase in progression over time and generate unexpected secondary events of strong impact. These are often at least as serious as the original event and contribute significantly to the overall duration of events.



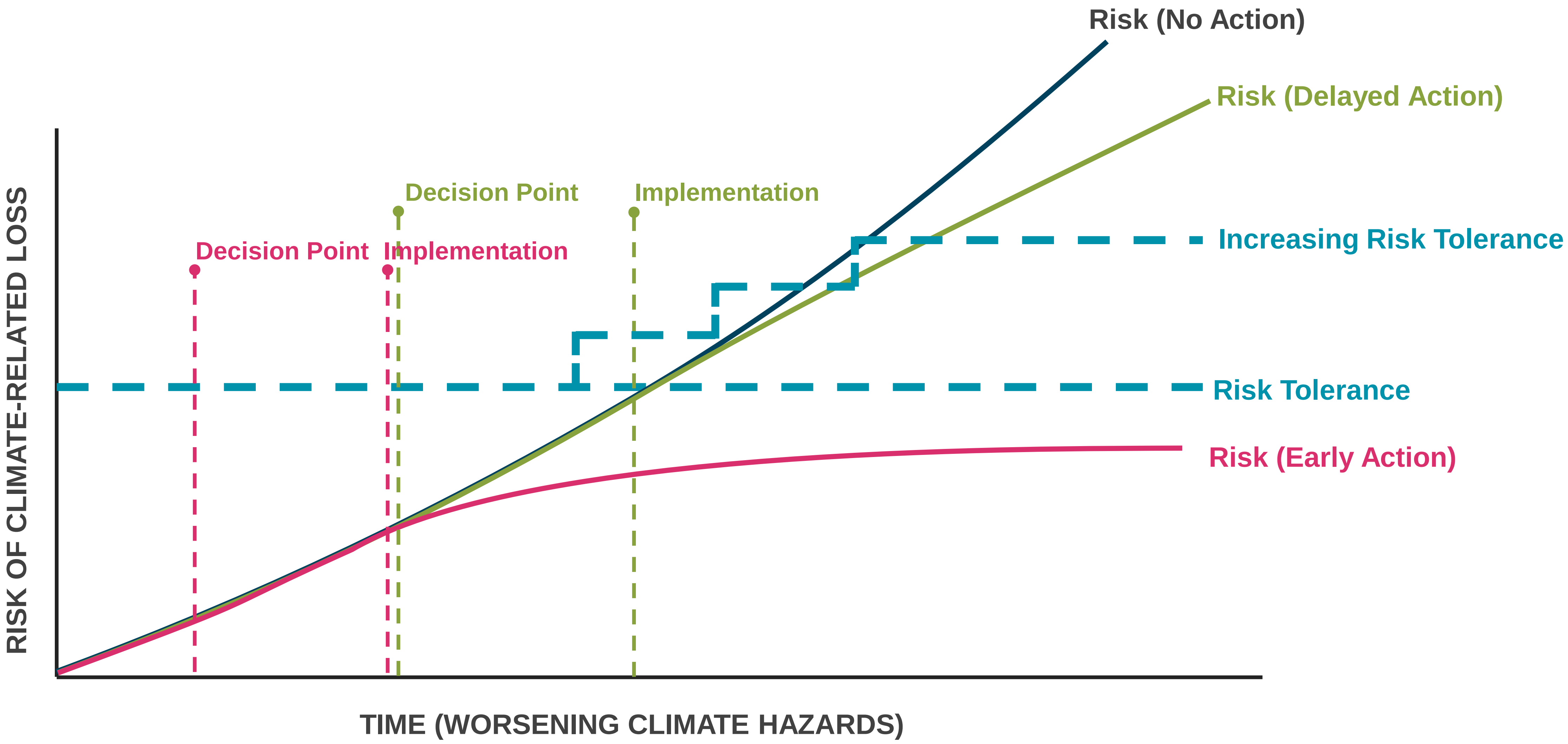
Graphics by: UNDRR

Time Scale


structure
services
stuff
space plan
skin


wetlands, preserves, ecosystems, surrounding habitats
major infrastructure, programmed outdoor space, buildings
structural systems, plantings/landscaping
MEP systems, on-site energy, building envelope
Finishes, FFE, MEP components
20
40
60
80
100
Anticipated Lifespan (years)

Critical Decision Points



Risk Tolerance Examples

	Extreme Heat	Flooding	Drought	Wildfire	Energy Insecurity
People	No net increase in heat health events by managing exposure and readiness for coping with system failure.	No net increase in flood-related health events	No net increase in water demand beyond FDOB targets	No net increase in smoke-related, or fire-related injury. No net loss of working hours during wildfire season.	No negative health impacts; No interruption to work
Buildings	N… U…	No net occupancy loss of residential or workplace buildings. Sustained access/emergency egress.	Sustained access to potable water and flushing toilets during shelter in place events; no subsidence-driven losses; Maintenance of indoor air quality during high dust events	…d, or …ldings.	No net loss in residential building functionality; Accessibility to cooling centers; Targeted drawdown on office functions to redirect resources toward residential buildings
Open Space	H… m… channeling	N… sp… D…	…,	…play, … to … ents are not safely occupiable due to smoke. Districts must manage ecosystems for wildfire readiness and recovery.	…ate …nce …ated
District Infrastructure	System readiness, in concert with passive strategies, for increased demand load	Demonstrable graduated flood response in alignment with flooding thresholds	…nd	Districts must have demonstrable capacity to manage smoke impacts on district infrastructure.	…ate …ce …ated
Regional/ Municipal Systems	Preparation for city/municipal failures	Preparation for municipal failure and need to self-manage district resources for passive habitability and ongoing operations	Recognizing growing public water shortages, consider extent to which Google Districts can be independent of municipal water systems	Districts must have backup resources for those services provided by the municipalities (water, power) that may be purposefully taken offline as part of preemptive measures or may lose capacity during redirection efforts for wildfire responses.	Districts must have ability to operate district infrastructure without reliance on municipal services for a designated period of time

No net increase in heat health events by managing exposure and readiness for coping with system failure.

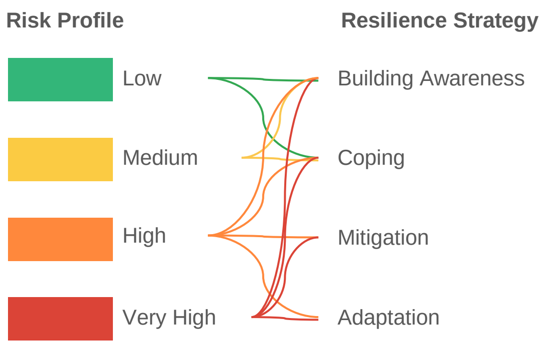
No net occupancy loss of residential or workplace buildings. Sustained access/emergency egress.

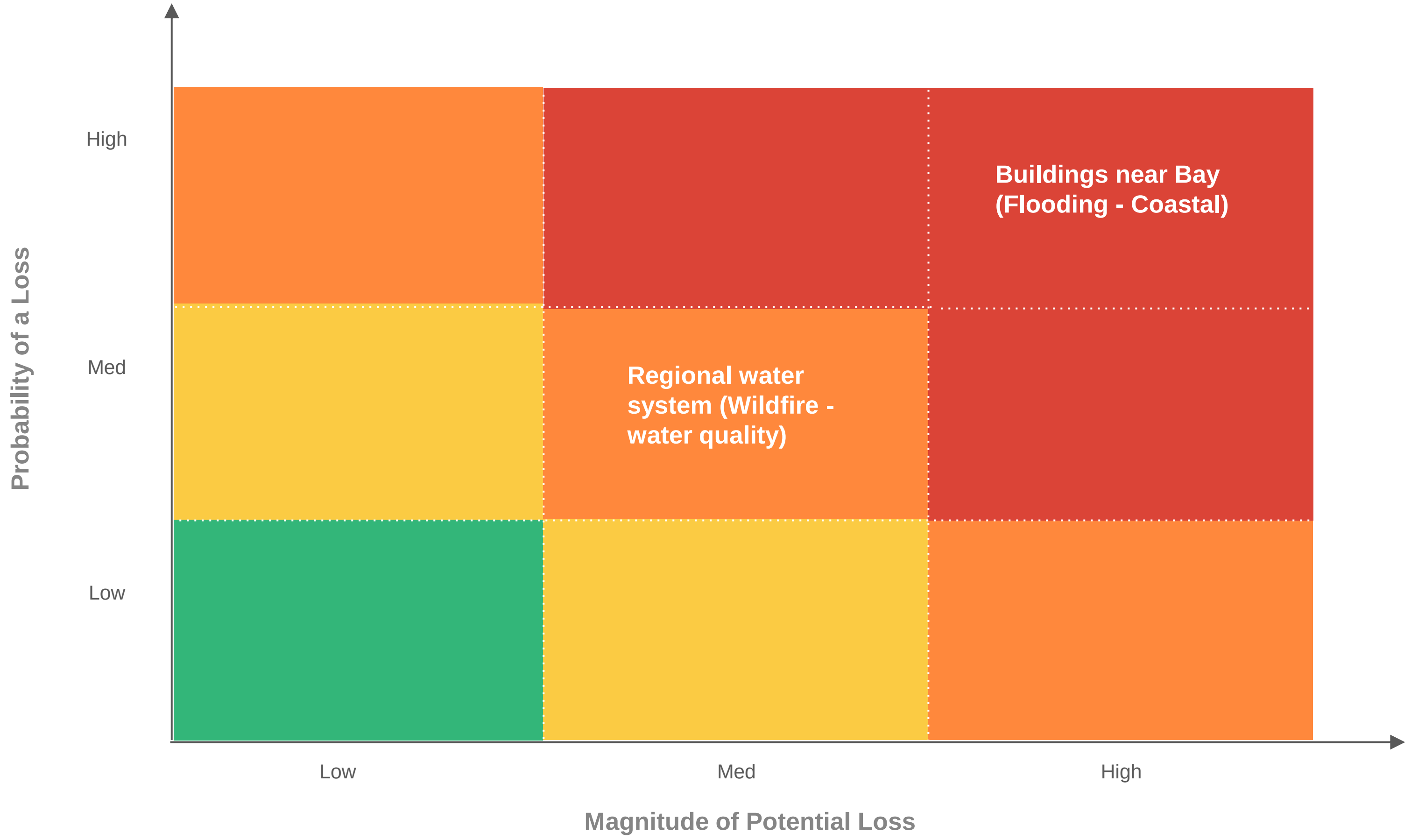
Sustained access to potable water and flushing toilets during shelter in place events; no subsidence-driven losses; Maintenance of indoor air quality during high dust events

No net increase in smoke-related injury. No net loss of working hours during wildfire season.

No net loss in residential building functionality; Accessibility to cooling centers; Targeted drawdown on office functions to redirect resources toward residential buildings

Risk Profile





Adaptation Pathways

State of California / County / Municipal Code Requirements	Current Building Standards Pathway	District Sustainability Pathway	New Development Adaptation Pathway	Full Portfolio Adaptation Pathway
Do Even Less	**Do Less**	**Implement Sustainability**	**Partial Portfolio Adaptation**	**Full Portfolio Adaptation**
Meet Existing Code Requirements	Keep to current standards only, no additional notification/ awareness or coping programs	Rely on sustainability strategies identified for the district, existing notification programs & better existing development risk awareness	**Improve new developments** to respond to climate hazards and increase engagement to build awareness and coping for risks	Improve new developments **and existing portfolio** to respond to climate hazards and increase engagement to build awareness and coping for risks

Extreme Heat + Energy Insecurity

Buildings

Additional Strategies

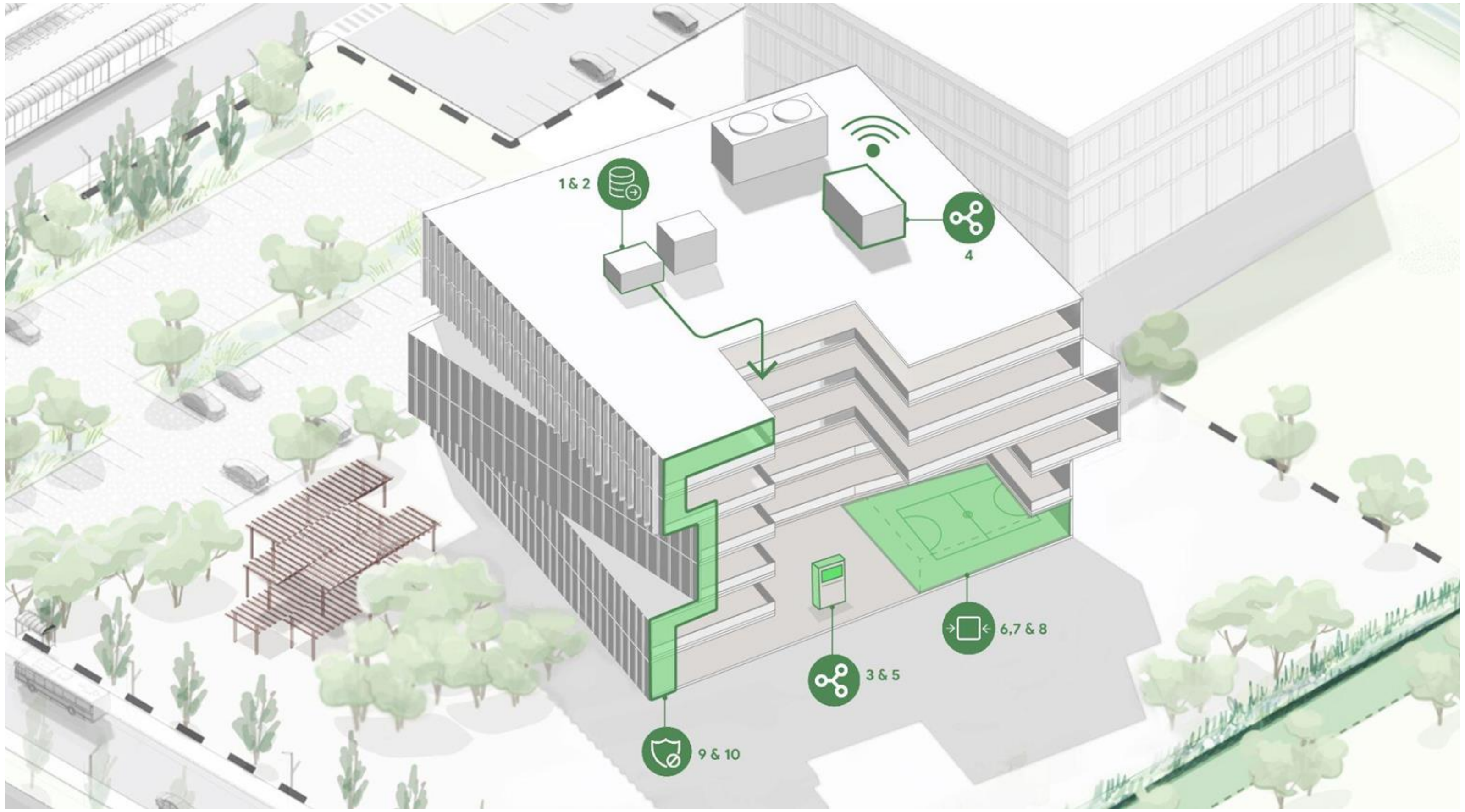
Additional Resilience Strategies

Relocate
1. Relocate critical equipment
2. Keep equipment cool / reduce congestion

Connect
3. Visualize building data for occupants
4. Remote building management
5. Automation with manual override

Accommodate
6. Dormant spaces/ cool rooms
7. Indoor exercise areas
8. Demand shifting

Defend
9. System redundancy - PV/BESS
10. System redundancy - islanding capability
11. Increase interior thermal mass



Open Space

Plant Stormwater Tolerant Species

Defend

Hazards Addressed:

Strategy Description:

Plant species characteristics are important in effective flood resilience strategies. Plant design should tend toward stormwater resistant species in areas at risk of flooding. These species will help reduce damage by encouraging the growth of root systems which stabilize banks and prevent erosion.

Performance Metrics:

- # stormwater tolerant plant species
- Area covered by stormwater tolerant plant species

Case Studies:

- Plants for Swales (Minnesota Stormwater Manual)
- Georgia Stormwater Management Manual

Image Source: http://www.3riverswetweather.org/

Buildings

Dormant Buildings

Accommodate | Relocate

Hazards Addressed:

EXTREME HEAT

ENERGY INSECURITY

Strategy Description:

During hazard events buildings can be assigned to shut off or become dormant. This will allow for energy savings when there is an energy insecurity event. Buildings can be partially or fully dormant, and some active buildings may be assigned an altered program to accommodate for occupant needs. The system energy saved from the dormant buildings will allow for the preservation of cool buildings and program function during hazard events.

Performance Metrics:

- # of dormant or partially dormant buildings
- # of buildings with altered program

Case Studies:

[Building America Solutions Center Design for Extreme Heat Guide]

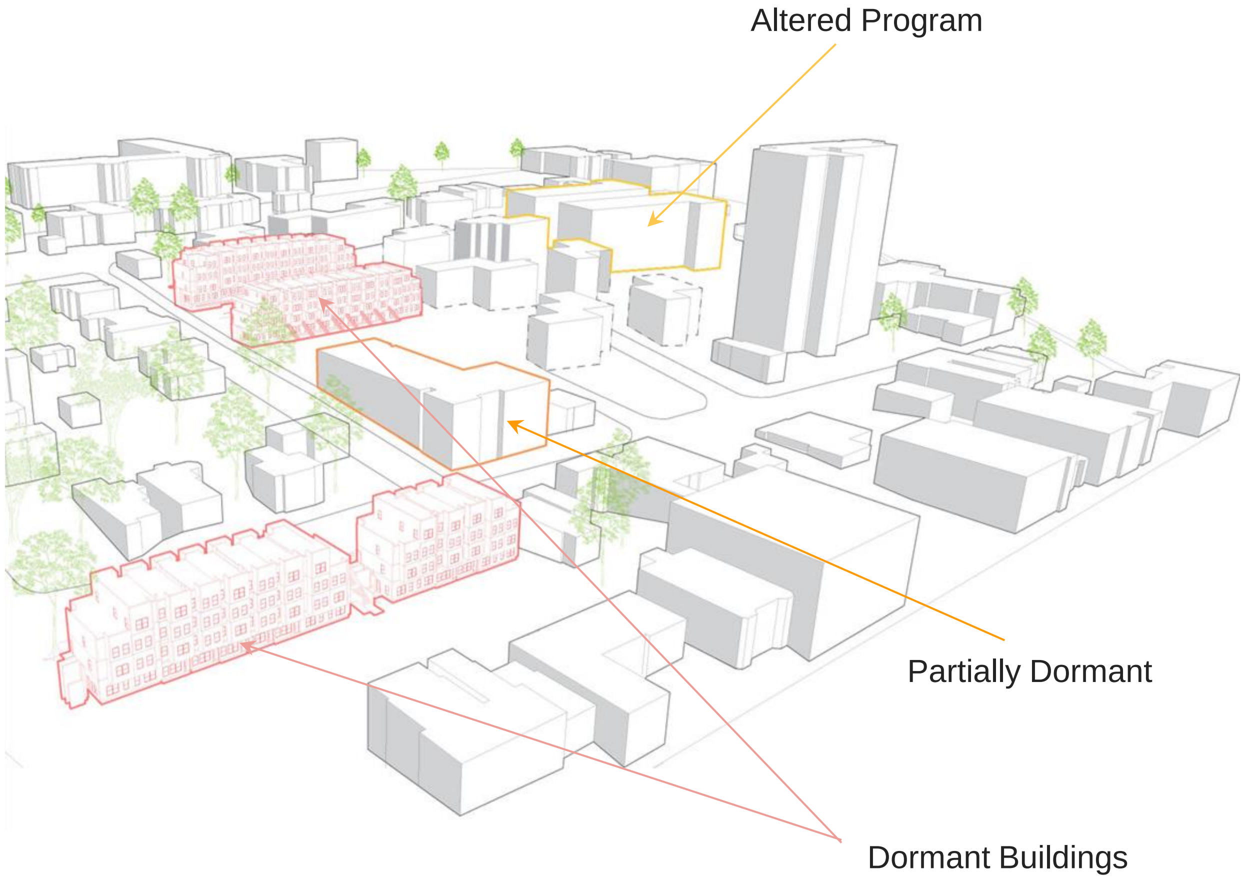
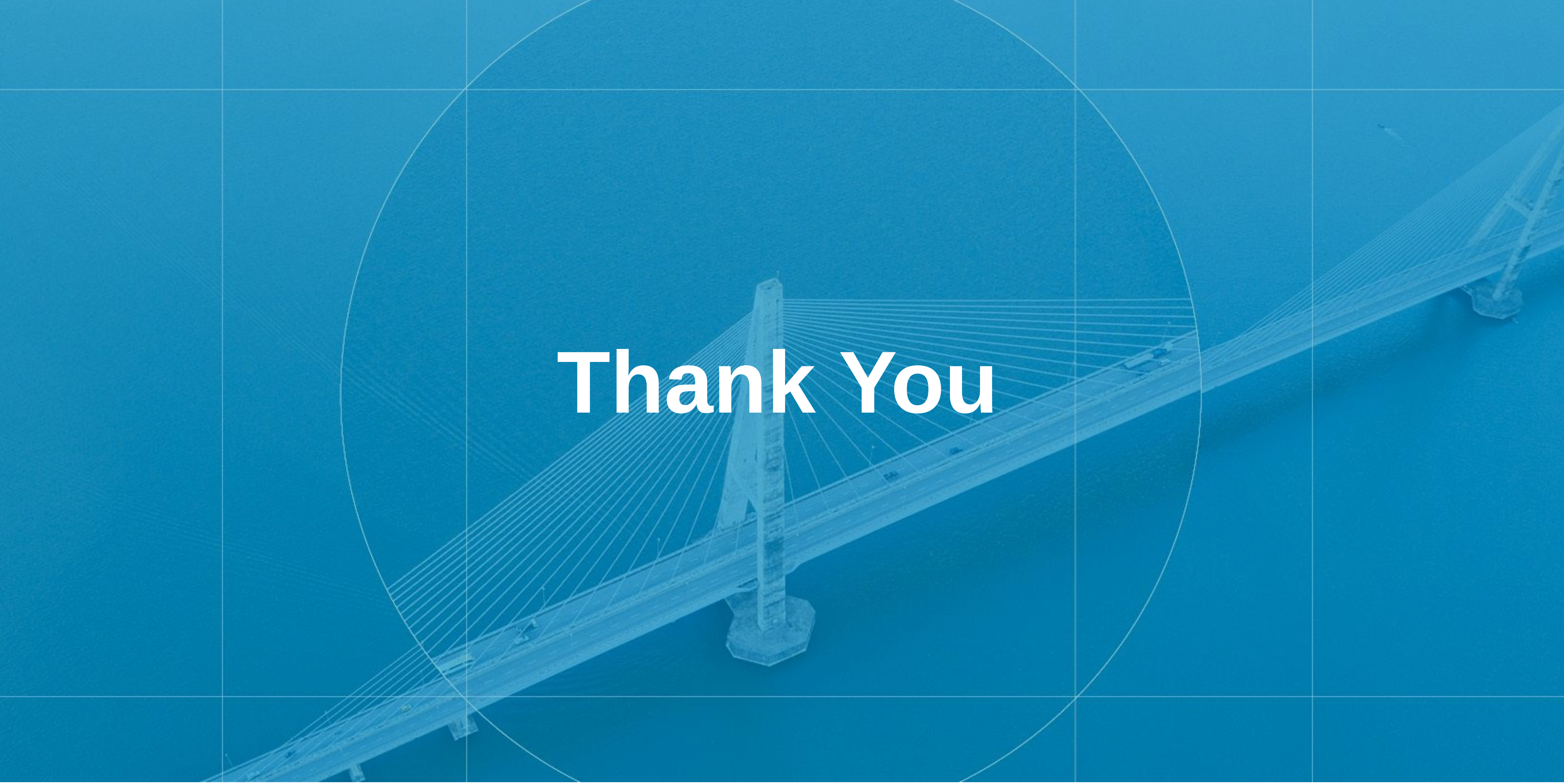


Image Source:
https://www.maparchitects.com/cottage-gardens-redevelopment

Q&A


Thank You