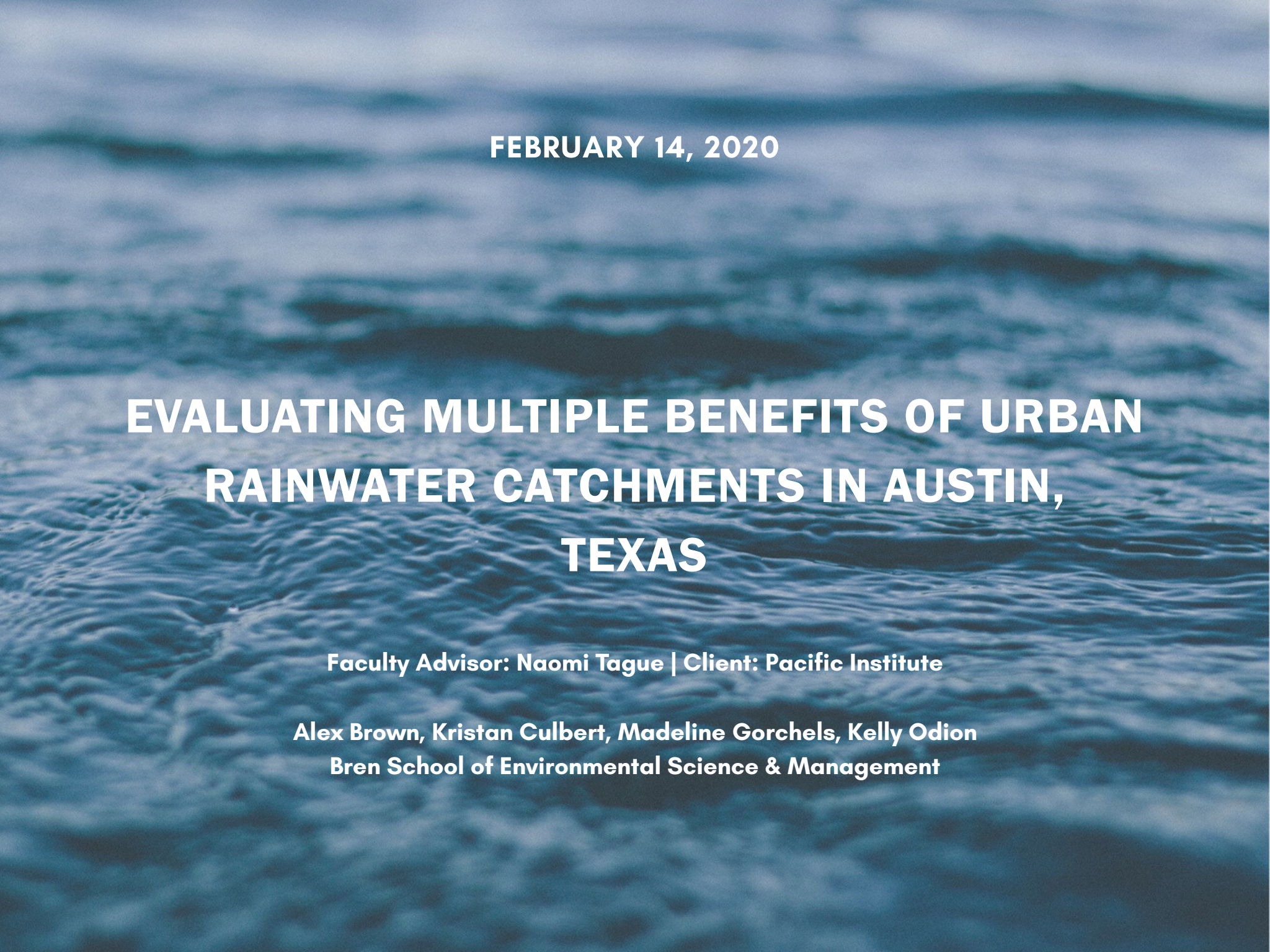


FEBRUARY 14, 2020

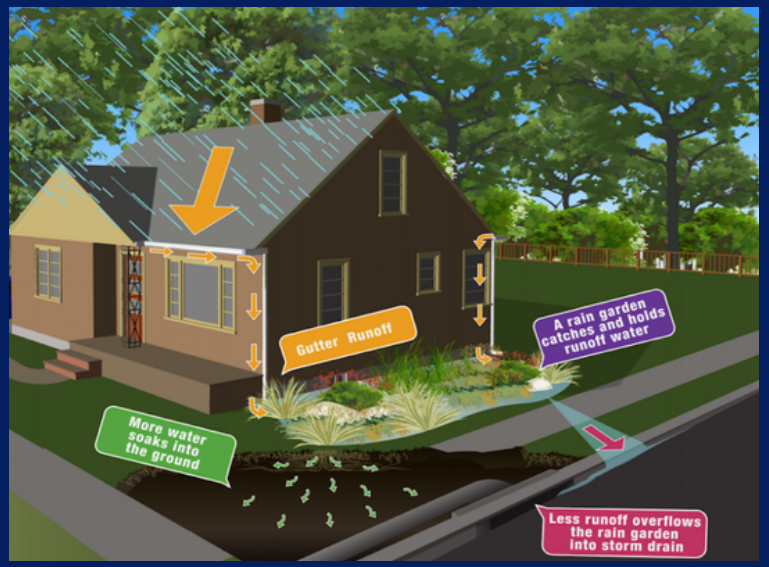
EVALUATING MULTIPLE BENEFITS OF URBAN RAINWATER CATCHMENTS IN AUSTIN, TEXAS

Faculty Advisor: Naomi Tague | Client: Pacific Institute

Alex Brown, Kristan Culbert, Madeline Gorchels, Kelly Odion
Bren School of Environmental Science & Management

WHAT ARE URBAN RAINWATER CATCHMENTS?

- Rain Gardens
- Rain Cisterns
- Bioswales
- Curb Cuts
- Green Roofs
- Retention Ponds



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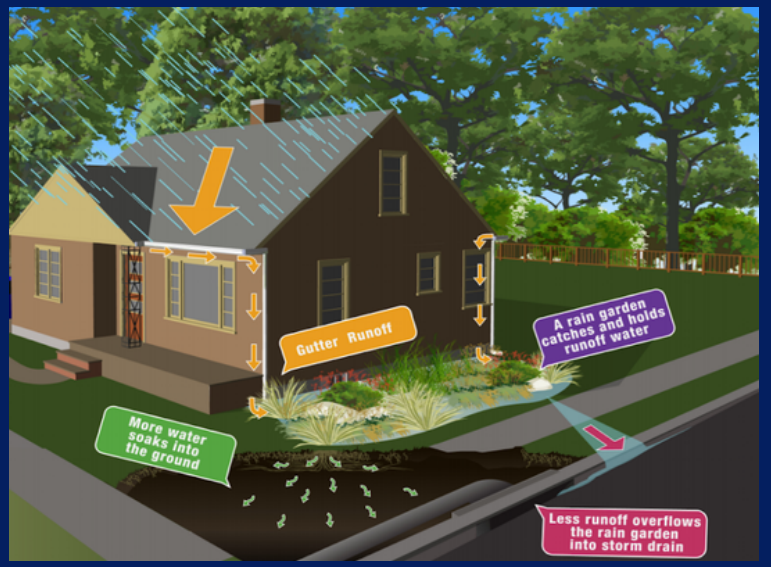


WHY IMPLEMENT URBAN RAINWATER CATCHMENTS?

RAINWATER CATCHMENTS COULD HAVE ADDITIONAL CO-BENEFITS

And more!

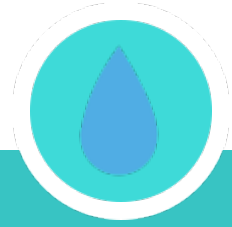
PACIFIC INSTITUTE'S MULTI-BENEFIT FRAMEWORK

A framework for identifying and analyzing potential co-benefits from water management projects

ENERGY

PEOPLE & COMMUNITY

RISK & UNCERTAINTY



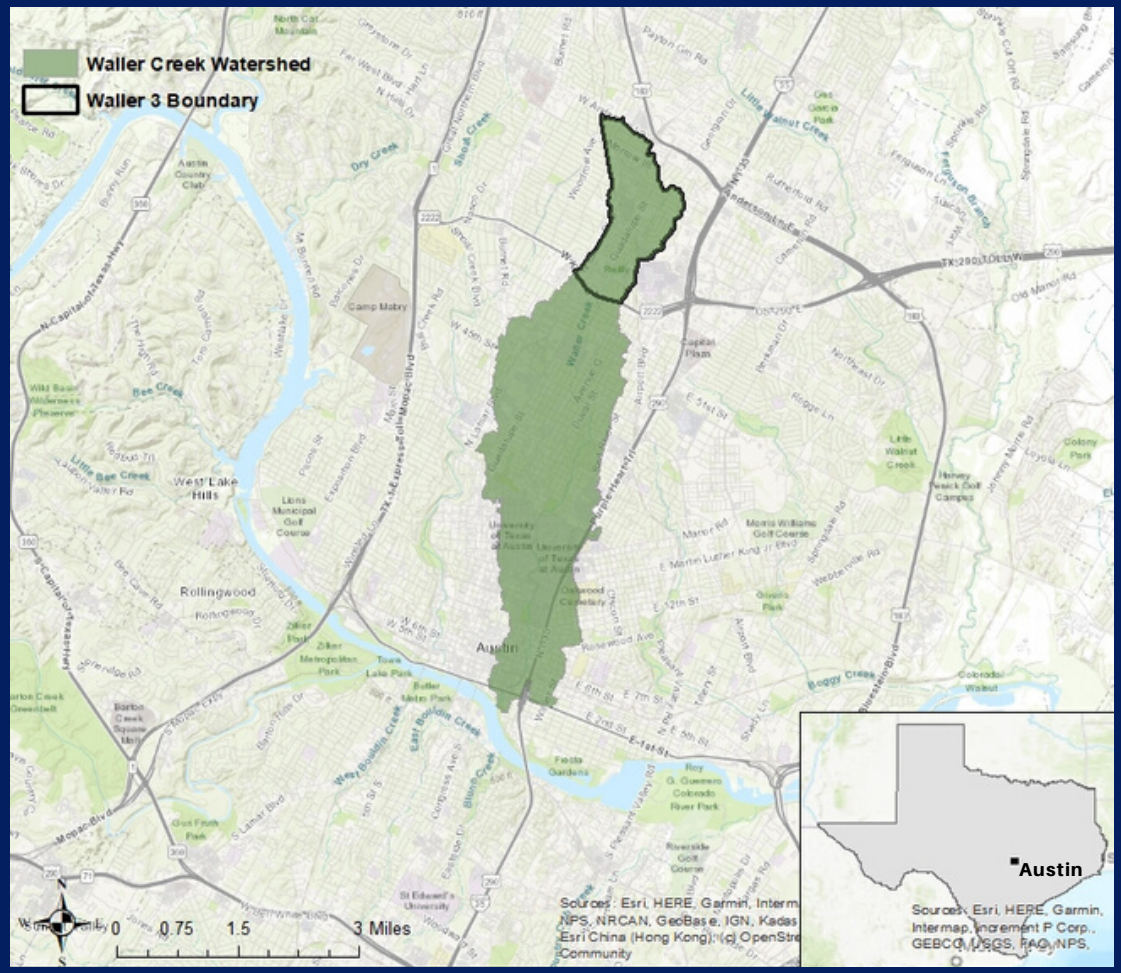
WATER

LAND & ENVIRONMENT

WALLER 3 RAIN CATCHER PILOT PROGRAM (RCPP)

- Residential neighborhood in north Austin's upper Waller watershed selected for City's rain catcher pilot program (RCPP)

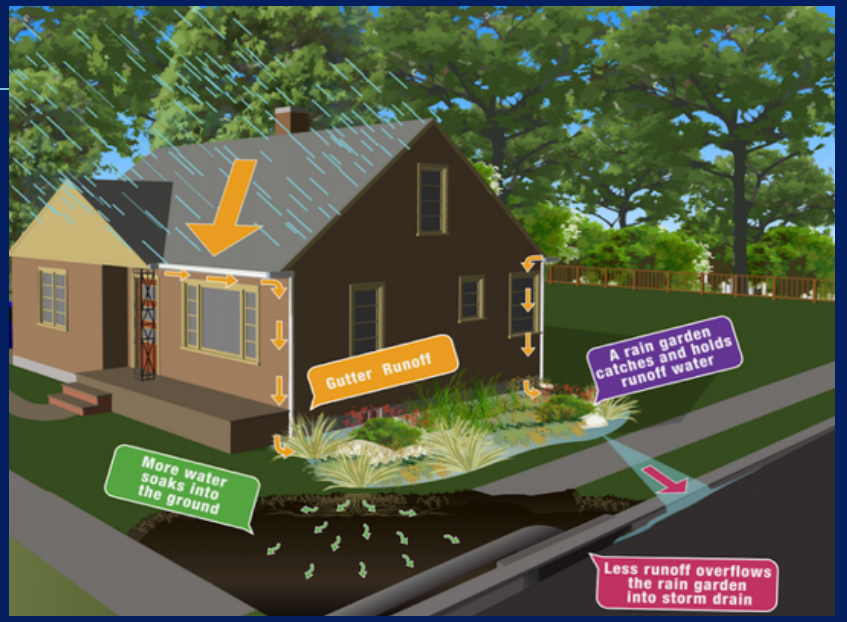
- Goal: 75% household participation
  - 1200 homes over 3 years



WALLER 3 RAIN CATCHER PILOT PROGRAM (RCPP)

- **Rain Gardens**
  - Rainwater retention and infiltration
  - 100 cubic feet
  - Homeowners may add trees via voucher program

- **Rain Cisterns**
  - Rainwater storage for irrigation
  - Capacity: 1000-gallon tanks



APPLYING THE MULTI-BENEFIT FRAMEWORK

Bren Group Project

Pacific Institute/City of Austin

PROJECT OBJECTIVES

1. Quantify energy savings from reduced potable water demand produced by RCPP

2. Quantify the RCPP's effect on urban heat island incidence in the Waller-3 project area

3. Evaluate potential opportunities for incorporating equity into the RCPP

4. Compile useful resources for future users of the multi-benefit framework

RAIN CATCHER PILOT PROGRAM &

POTABLE WATER OFFSETS

OBJECTIVE: QUANTIFY ENERGY SAVINGS FROM POTABLE ENERGY REDUCTIONS

STEP 1

Understand Austin's water system and determine affected steps.

STEP 2

Calculate energy intensity at different stages of water conveyance.

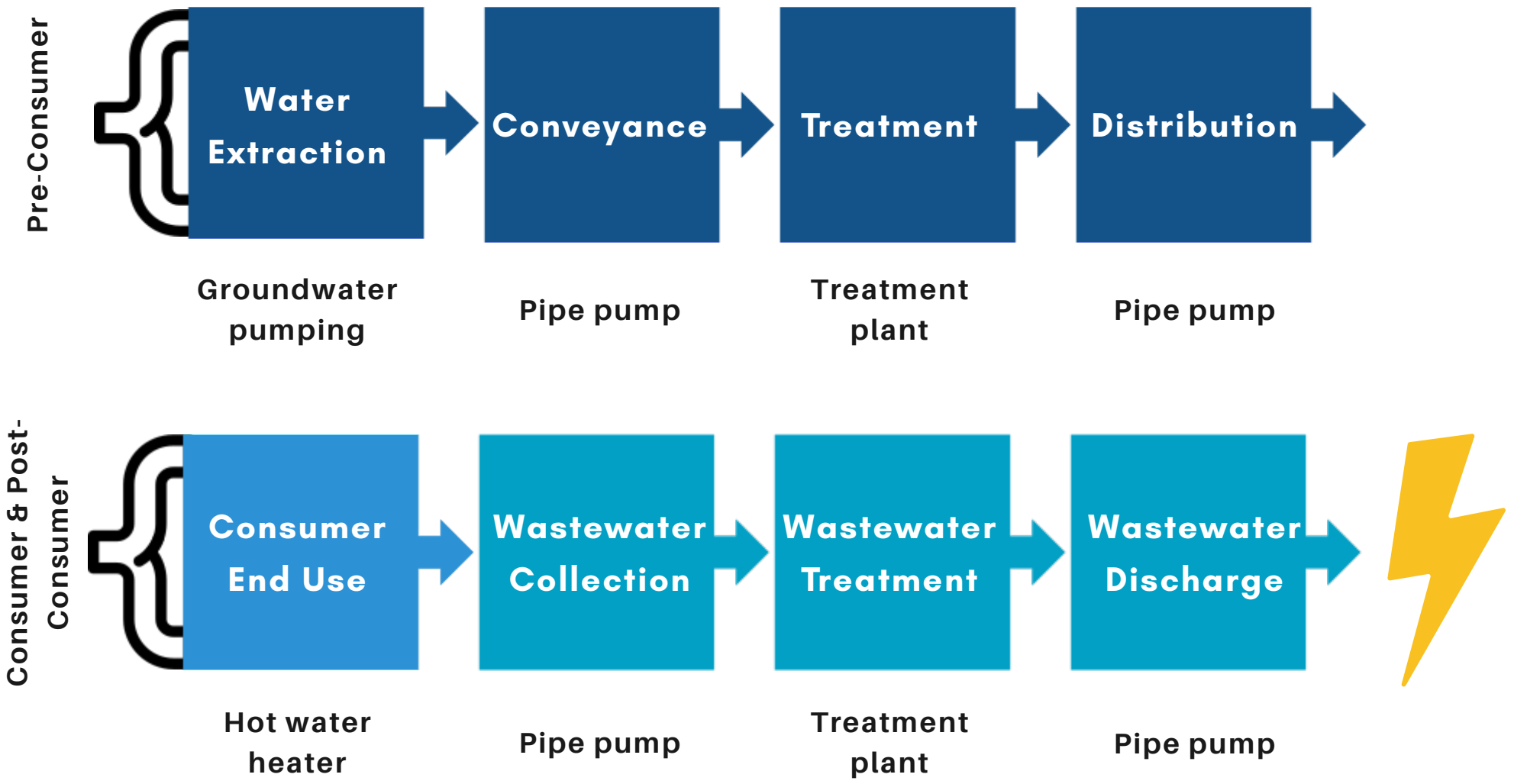
STEP 3

Create reasonable estimates of total possible energy reductions.

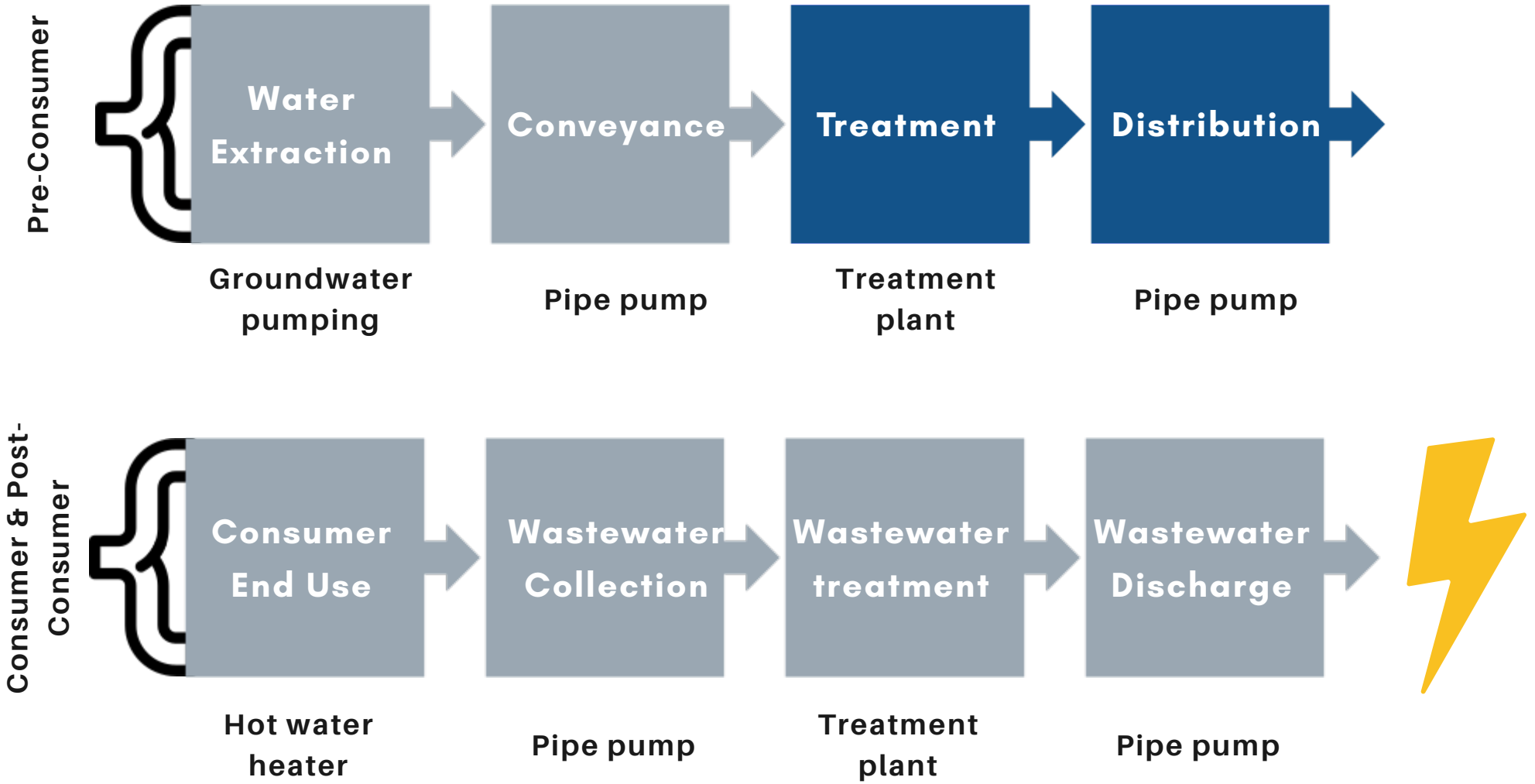
HOW IS POTABLE WATER OFFSET IN THE RCPP?

Rain gardens and cisterns allow for consumers to use accumulated water for landscape irrigation.

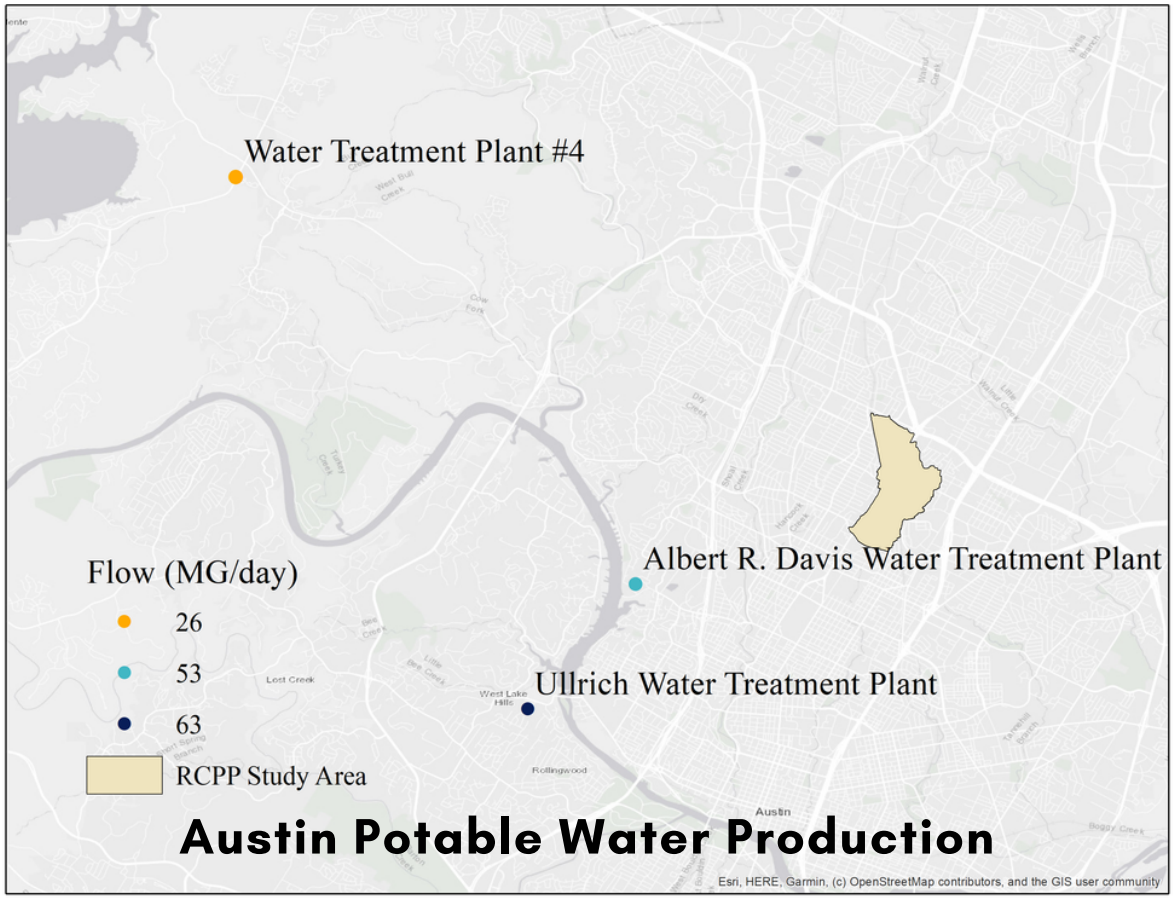
Energy of Potable Water: WESim Model

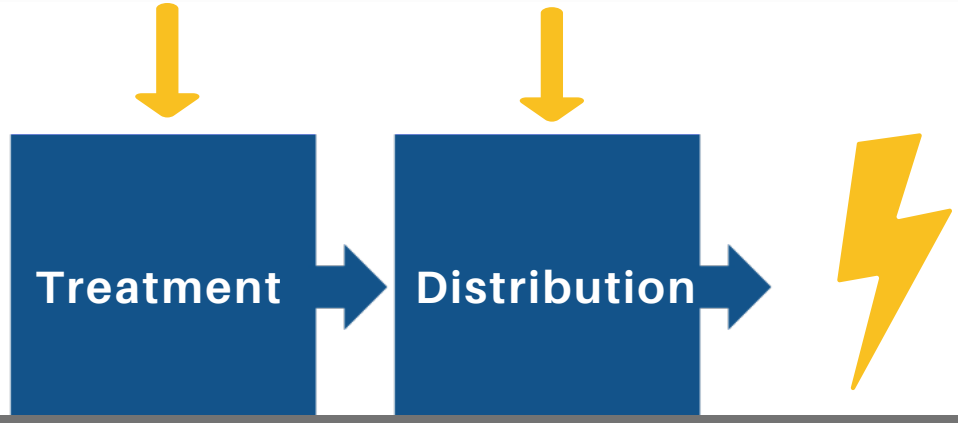


WESim in RCPP



WESim in RCPP





RESULTS

ENERGY

RESULTS: WESIM

Energy Savings:
2.2-2.8
kWh/1,000 gallons

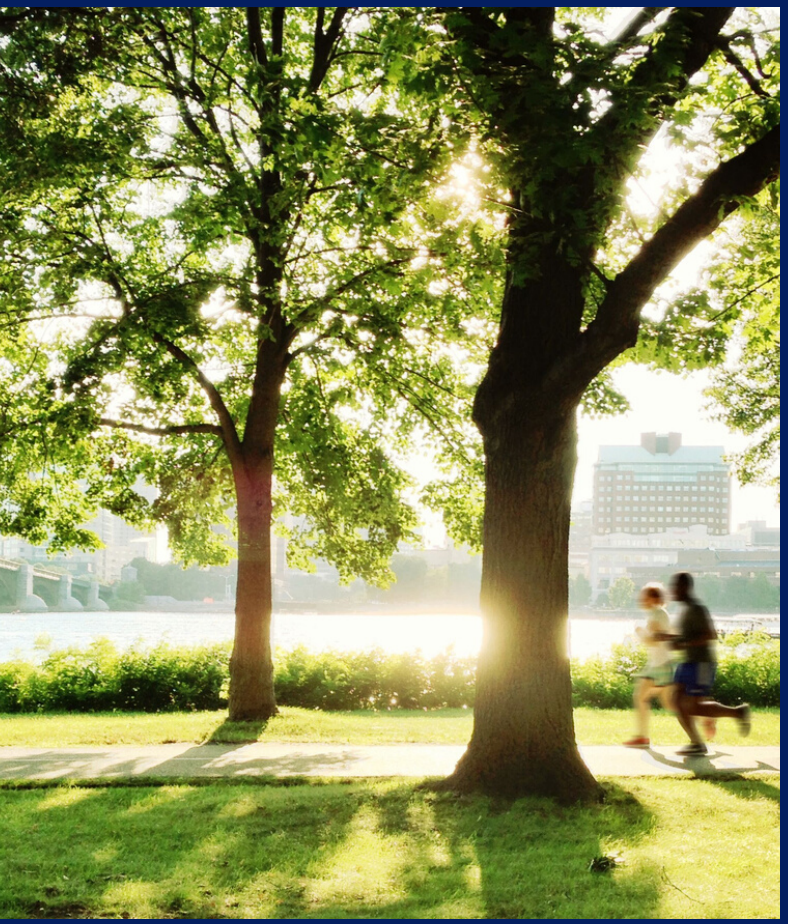
Emissions Reductions:
0.0015-0.0020
metric tons eq/1,000 gallons

~1600-2100 kWh
3.9-4.9 metric tons CO2 eq annually

RAIN CATCHER PILOT PROGRAM &

URBAN HEAT ISLAND REDUCTIONS

OBJECTIVE: QUANTIFY THE RCPP'S EFFECT ON URBAN HEAT ISLAND INCIDENCE IN WALLER



STEP 1

Identify incidence of urban heat island effects within the Waller-3 project area.

STEP 2

Calculate temperature reductions produced by RCPP.

STEP 3

Translate temperature reductions into residential energy savings.

WHY MEASURE UHI EFFECT?

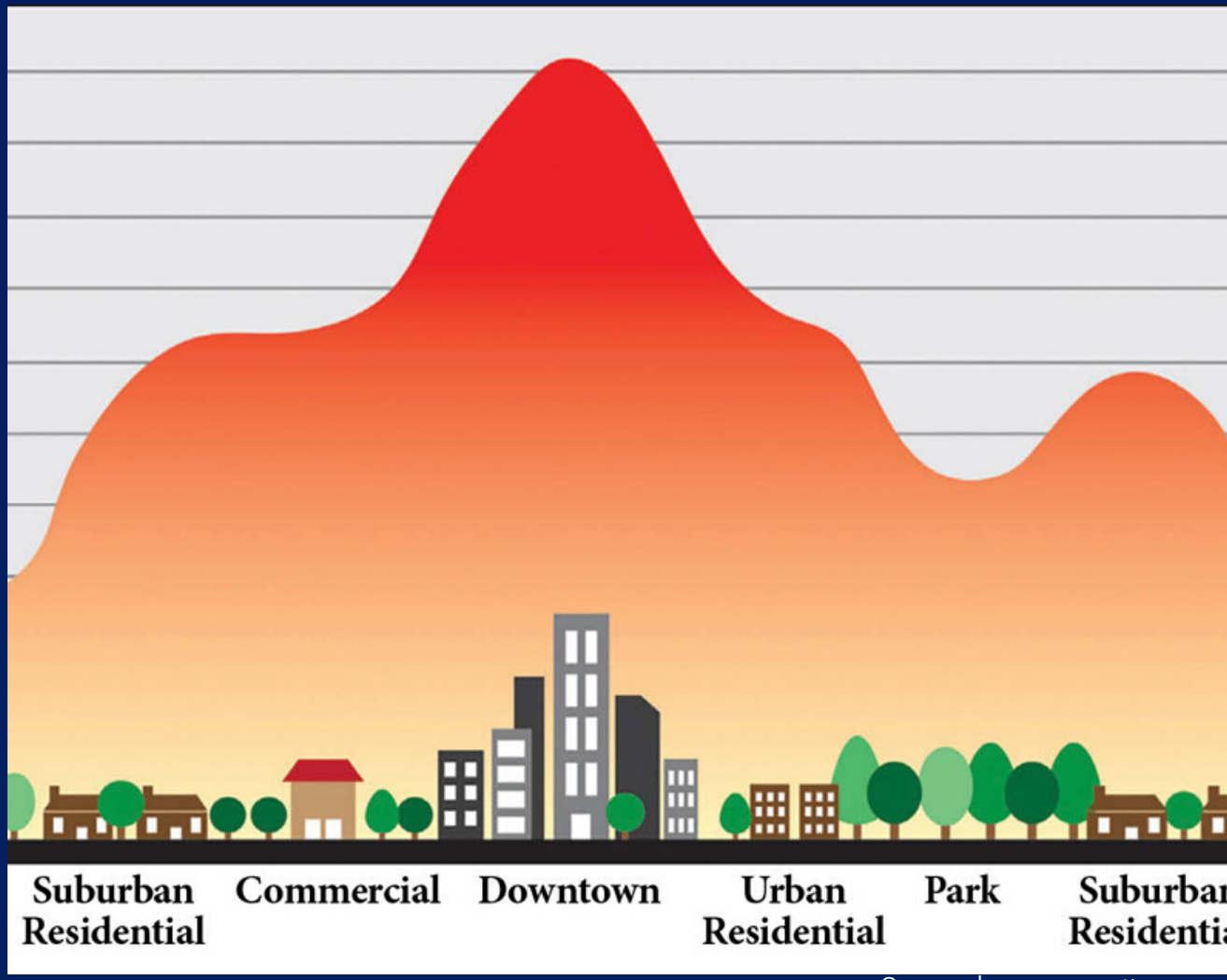
Urban areas can be up to 18 degrees F warmer than rural areas on a hot day, creating "heat islands".

Elevated urban temperatures can impact:

1. Human health

2. Livability

3. Energy consumption



Source: bayareamonitor.org

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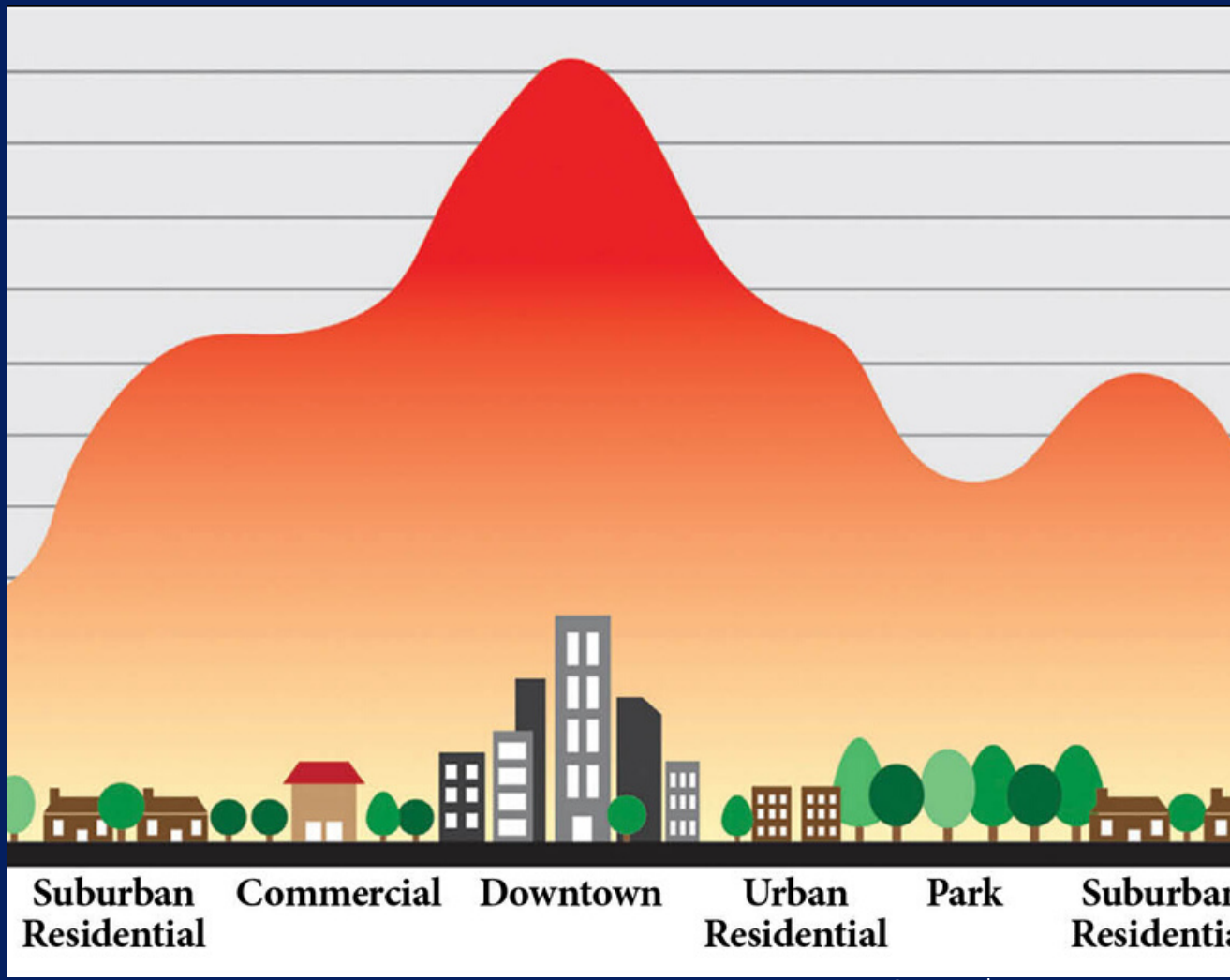
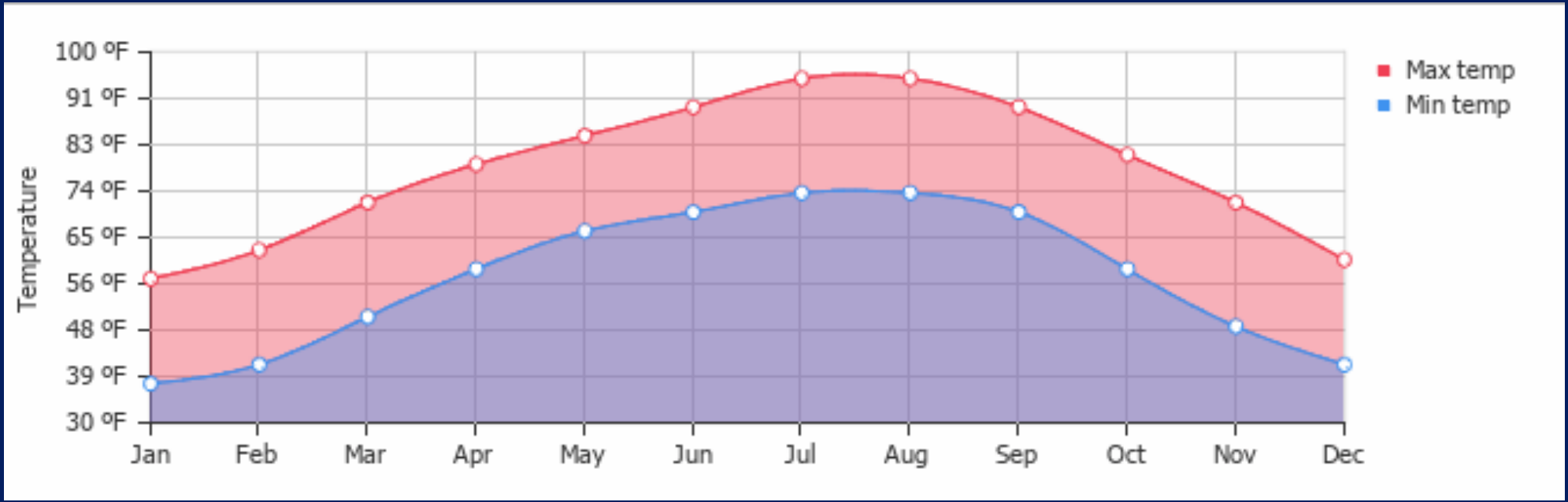


Source: bayareamonitor.org

WHY MEASURE UHI IN AUSTIN?

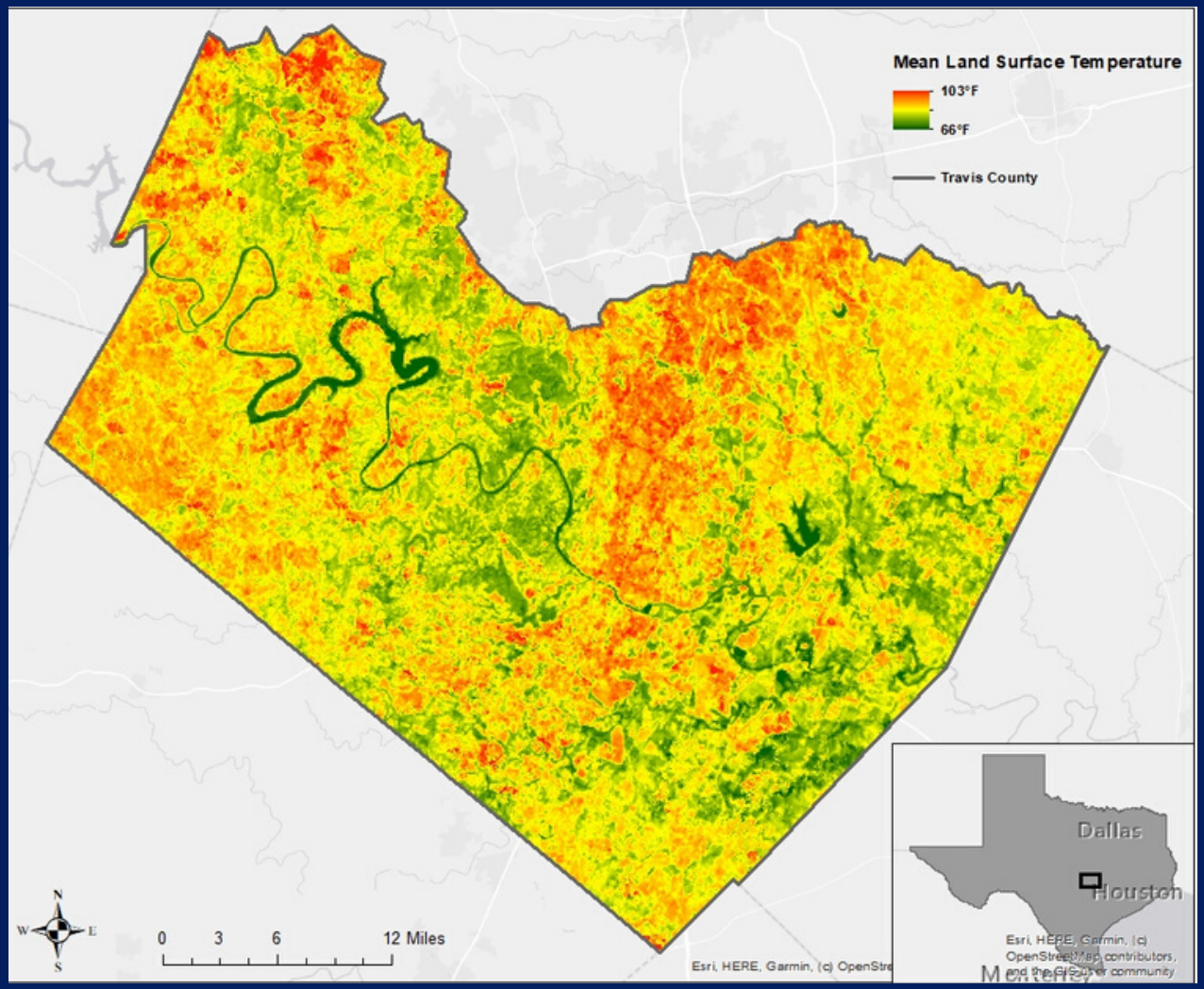
In Austin, average peak temperatures exceed **90 degrees Fahrenheit** in summer months.



Source: weather-and-climate.com

AUSTIN'S URBAN HEAT ISLAND

On average, rural areas in Austin are **5 degrees cooler** than urban areas.



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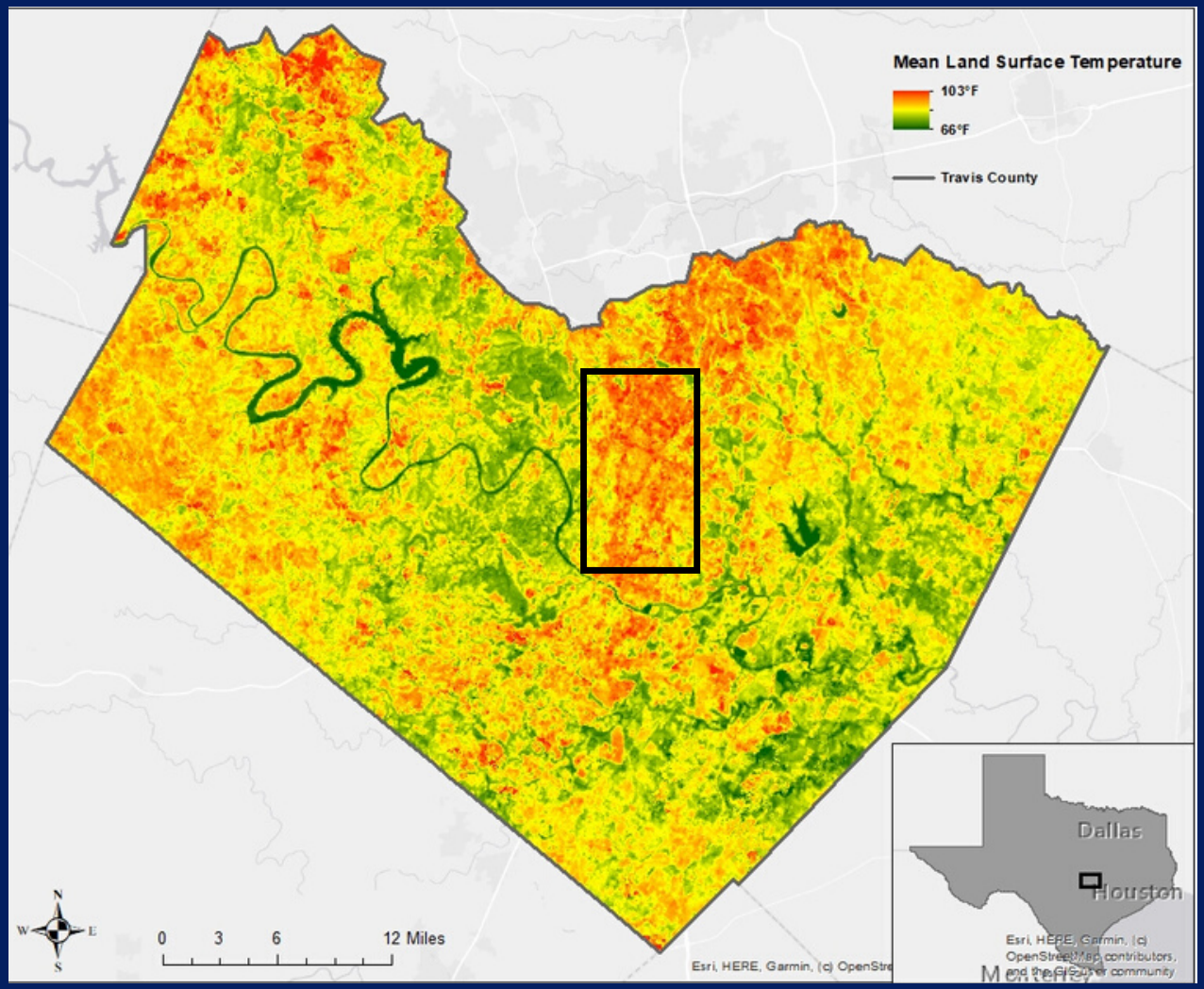

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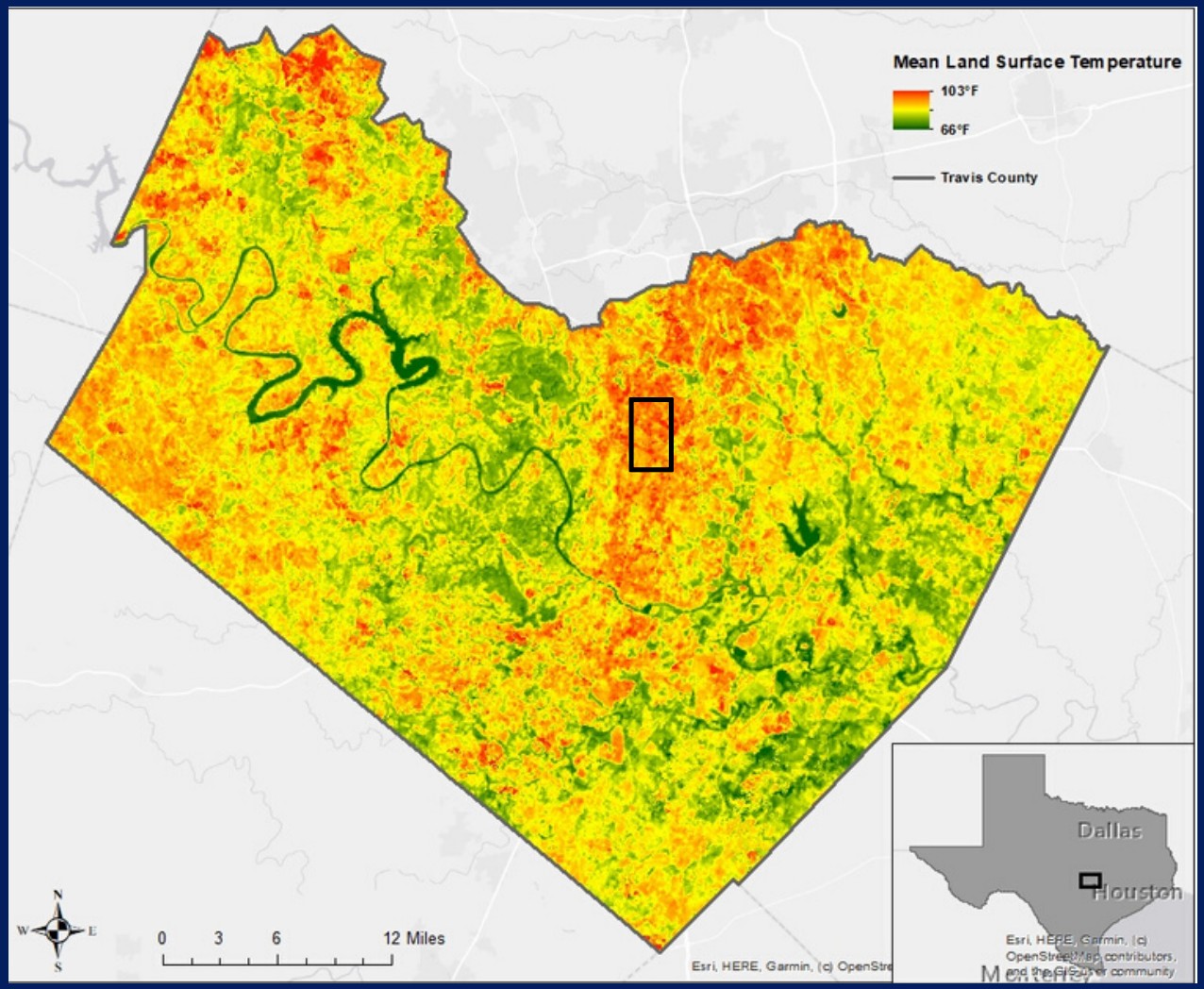


HOW DOES RCPP AFFECT UHI?

The RCPP is expected to cool temperatures through:

Increased evaporative cooling resulting from slow-release irrigation from rain cisterns and gardens

Increased shading and evapotranspiration resulting from planting trees adjacent to residences

QUANTIFYING UHI BENEFITS

We cannot observe the effects of RCPP on UHI because it has not yet been fully implemented.

Instead, we used two methods to estimate its benefits:

Modeled changes in summertime air temperature associated with additional irrigation and evapotranspiration before and after implementation of the RCPP

Estimated the effect of tree cover on an individual parcel using thermal remote sensing and tree cover data

APPROACH 1: SURFACE URBAN ENERGY WATER BALANCE SCHEME (SUEWS) MODEL

Meteorological Data:
Summer 2017, 2019 and projected 2050 hourly data

Surface Characteristics:
1. Land cover fractions
2. Tree age and species

Water Use:
1. Irrigation regulations
2. Cistern/garden adoption rate

SUEWS

Predicted Air Temperature

SUEWS MODEL SCENARIOS AND SENSITIVITY ANALYSIS

Meteorological Year

2017

2019

Projected 2050

SUEWS MODEL SCENARIOS AND SENSITIVITY ANALYSIS

Meteorological Year

2017

2019

Projected 2050

Tree Cover

High: 28% of land cover

Low: 27.9% of land cover

Status Quo: 27.8% of land cover

SUEWS MODEL SCENARIOS AND SENSITIVITY ANALYSIS

Meteorological Year

- 2017
- 2019
- Projected 2050

X

Tree Cover

- High: 28% of land cover
- Low: 27.9% of land cover
- Status Quo: 27.8% of land cover

X

Irrigation

- High: 75% adoption
- Moderate: 50% adoption
- Low: 25% adoption
- Status Quo

HOW WILL THIS TRANSLATE INTO RESIDENTIAL ENERGY SAVINGS?

Change in summertime temperature distribution (SUEWS 2017)

Change in Cooling Degree Days *(75.3°F for Southwest U.S.)*

2017 Austin residential energy consumption (kWh/year)

APPROACH 2: REMOTE SENSING ANALYSIS WITH LANDSAT

Thermal Data:
Land Surface Temperature Landsat 8 images averaged from April-September 2014

SPATIALLY-ADJUSTED REGRESSION

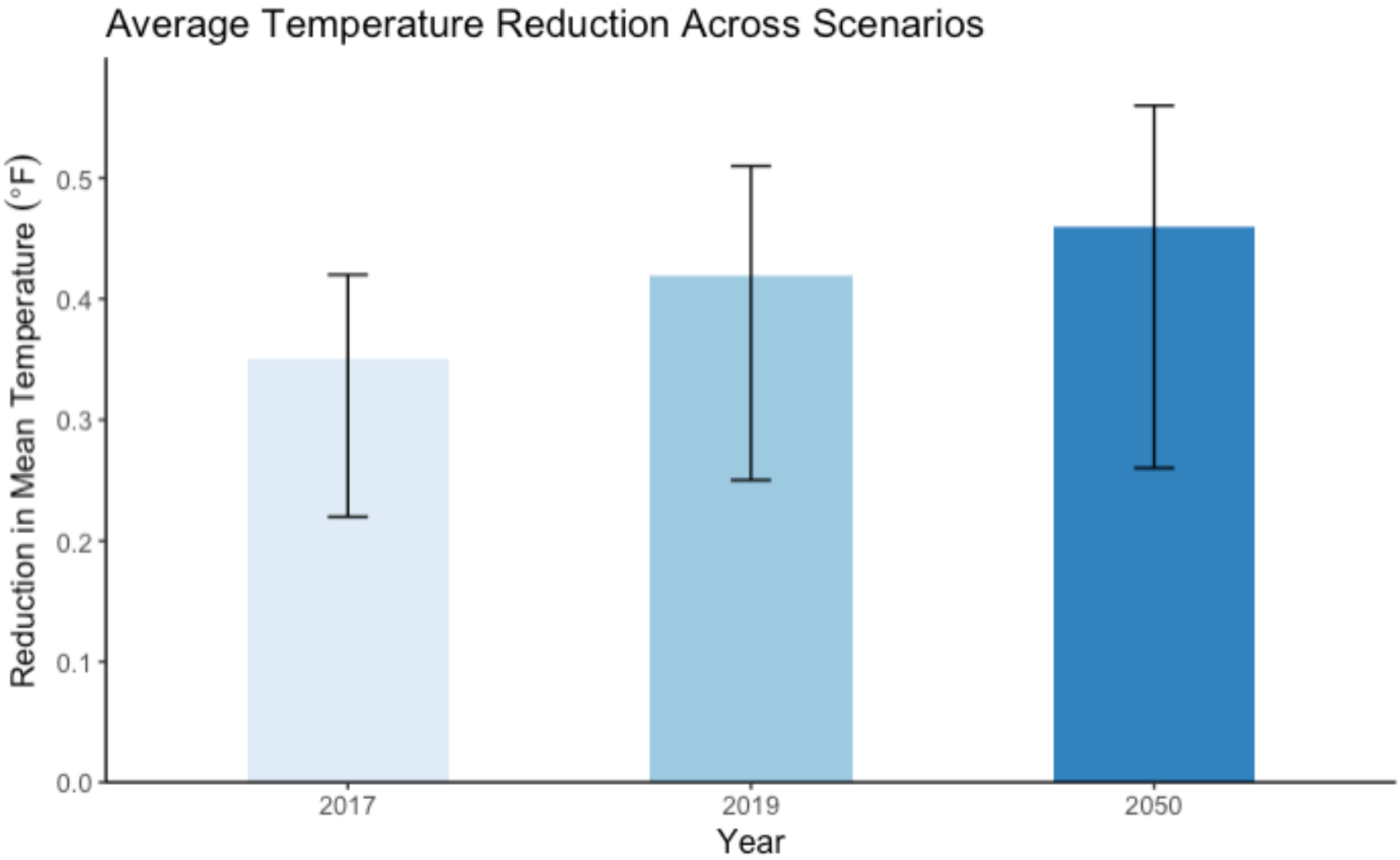
Average Difference in LST between shaded and non-shaded "parcel"

Surface Characteristics:
Tree canopy intensity from Landsat 8 images in 2014

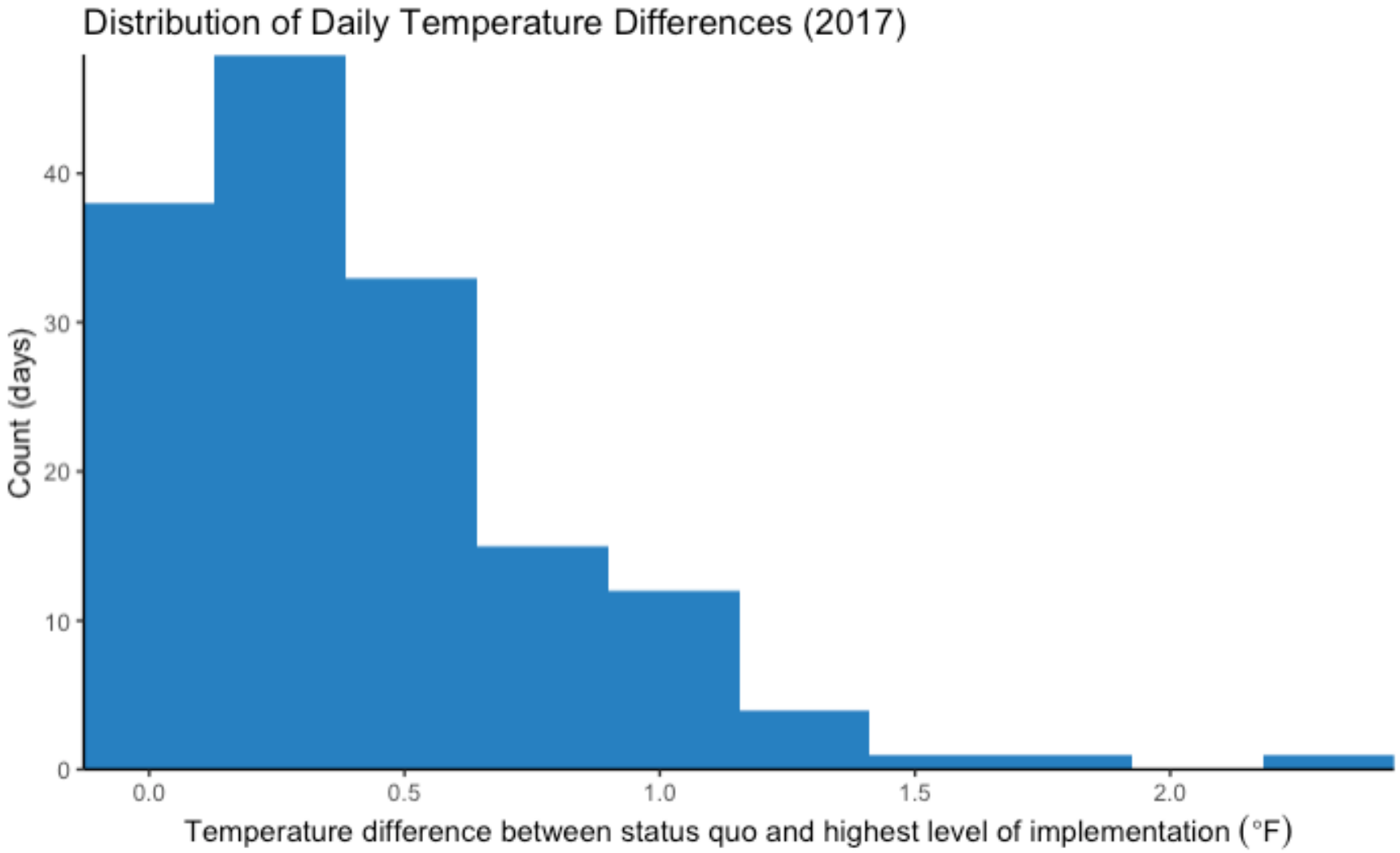
RESULTS

UHI

RESULTS: SUEWS MODEL



RESULTS: SUEWS MODEL



RESULTS: HOUSEHOLD ENERGY SAVINGS

Energy savings:

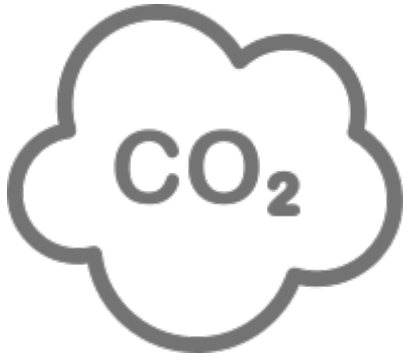
46 - 84 kWh/year

Monetary savings:

$5 - 9/year

Emissions reductions:

0.09 - 0.17 tons/year



RESULTS: AGGREGATE ENERGY SAVINGS

Energy savings:

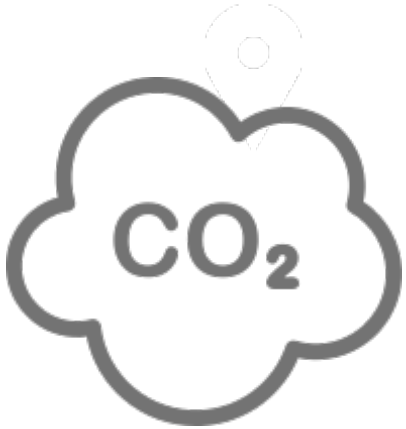
55,335- 100,233 kWh/year

Monetary savings:

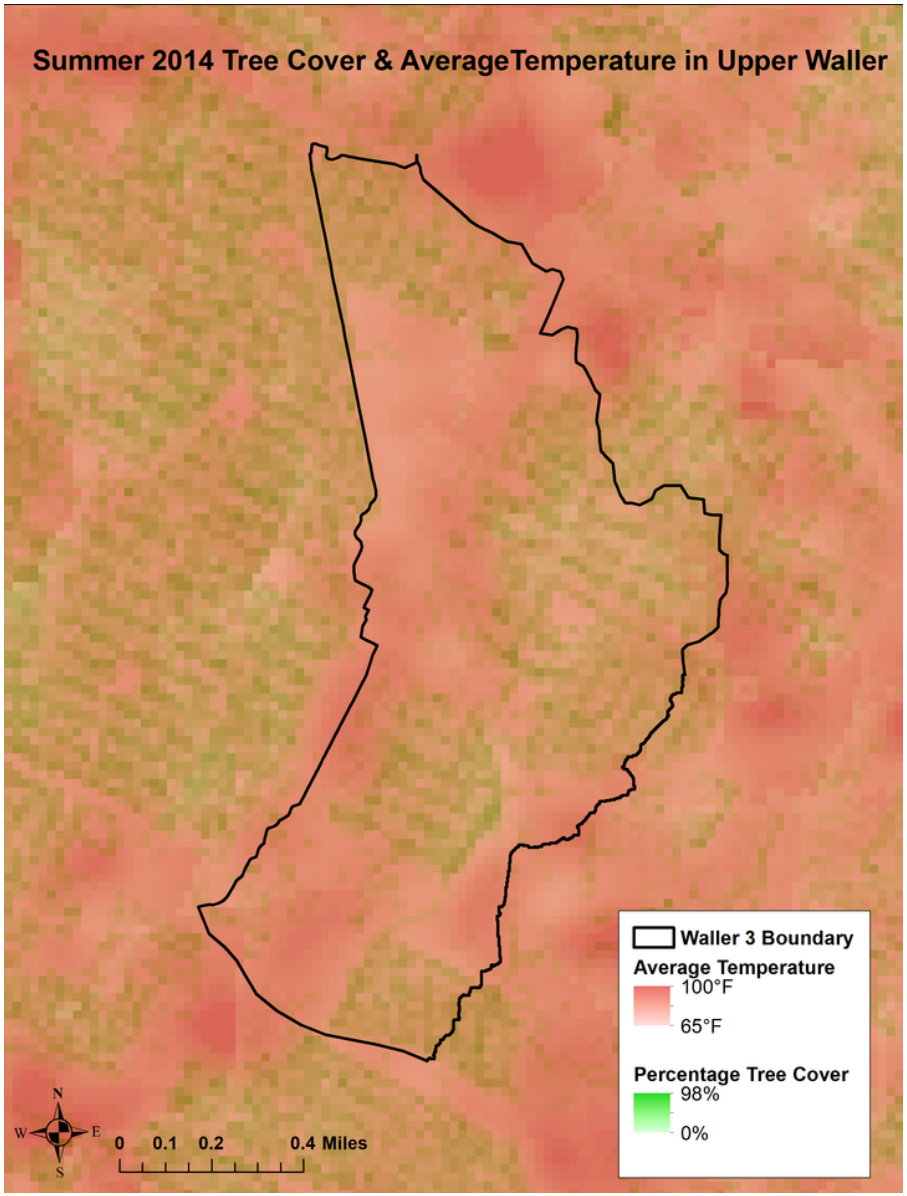
$5,815 -$10,534/year

Emissions reductions:

109-197 tons/year



RESULTS: REMOTE SENSING



Parcels that are tree covered are approximately **4.5°F cooler** than parcels with no tree cover

Mature trees cover parcel by 4-7%, leading to **0.16-.30°F cooling**

OBJECTIVE: EVALUATE POTENTIAL AREAS TO INCORPORATE EQUITY INTO THE RCPP

STEP 1

Identify current inequities.

STEP 2

Offer recommendations to the City of Austin.

STEP 3

Develop Decision-Maker Mapping tool.

INEQUITIES IN REBATE STRUCTURE

Rebate Benefits:

- Includes half of cost of materials and labor.
- Can apply every 12 months for system expansion till a cap of $5,000 is reached.

Potential Inequities:

- Must intend to keep service at least 5-10 years.
- Pay full price up-front.
- Wait 6-8 weeks to receive rebate check.

MAKING THE RCPP MORE ACCESSIBLE

1. Partner with local non-profits and/or apply for existing grants.

2. Continue to emphasize inter-agency benefits.

3. Include equity early in decision making process.

CONCLUSIONS

ENERGY REDUCTION FROM POTABLE WATER OFFSETS

The reduction in energy use from potable water offsets is up to 2.8 kWh/1000 gallons.

REDUCTION IN **UHI** FROM RCPP

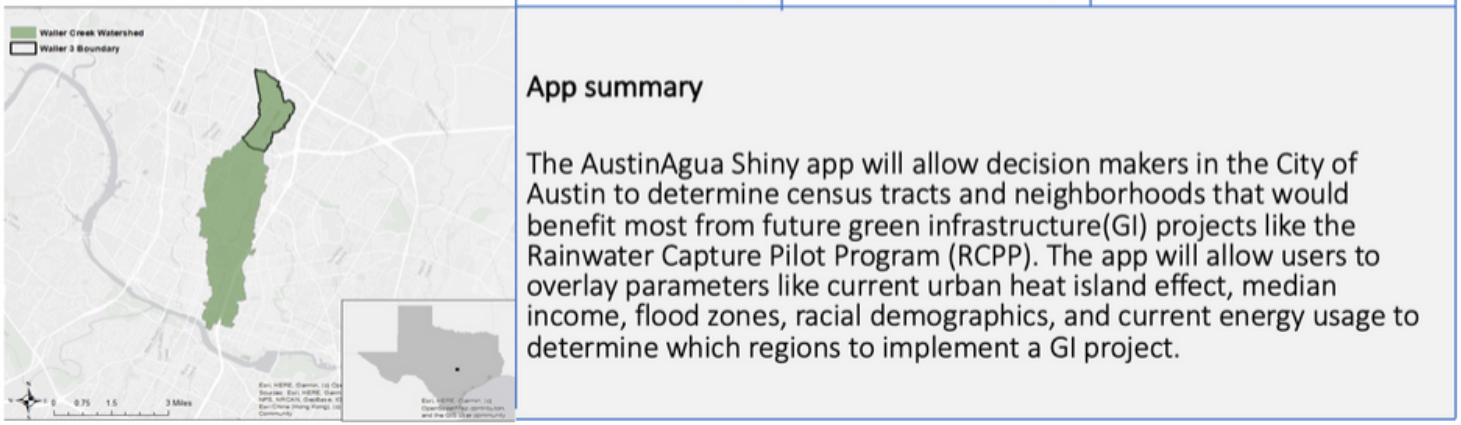
The neighborhood-scale reduction in UHI from rain cisterns & rain gardens is an average of 0.35 F, but can be greater on individual days and for individual homeowners.

ENERGY REDUCTION FROM DECREASE IN UHI

Reduction in residential energy consumption from decreased energy use is up to 100,000 kWh/year when aggregated.

NEXT STEPS

Evaluating Regions Best-Suited for Green Infrastructure in Austin, Texas



Layout of Shiny Mapping Application

ADDITIONAL SENSITIVITY ANALYSIS

DECISION-MAKER MAPPING TOOL

BEST PRACTICES FOR RCPP IMPLEMENTATION

TOOLS AND RESOURCES FOR MULTI-BENEFIT FRAMEWORK

ACKNOWLEDGEMENTS

DR. SARAH DIRINGER

Project Client
Senior Researcher
Pacific Institute

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Bren School of Environmental Science & Management

RACHEL TORRES

Ph.D Advisor
Bren School of Environmental Science & Management

DR. BOB WILKINSON

External Advisor
Bren School of Environmental Science & Management

Consultation on Multi-Benefit Framework

DR. KELSEY JACK

External Advisor
Bren School of Environmental Science & Management

Consultation on resource economics

DR. ALAN MURRAY

External Advisor
UCSB Department of Geogrpahy

Consultation on urban and spatial planning

Special thanks to:

PACIFIC INSTITUTE

PACIFIC INSTITUTE

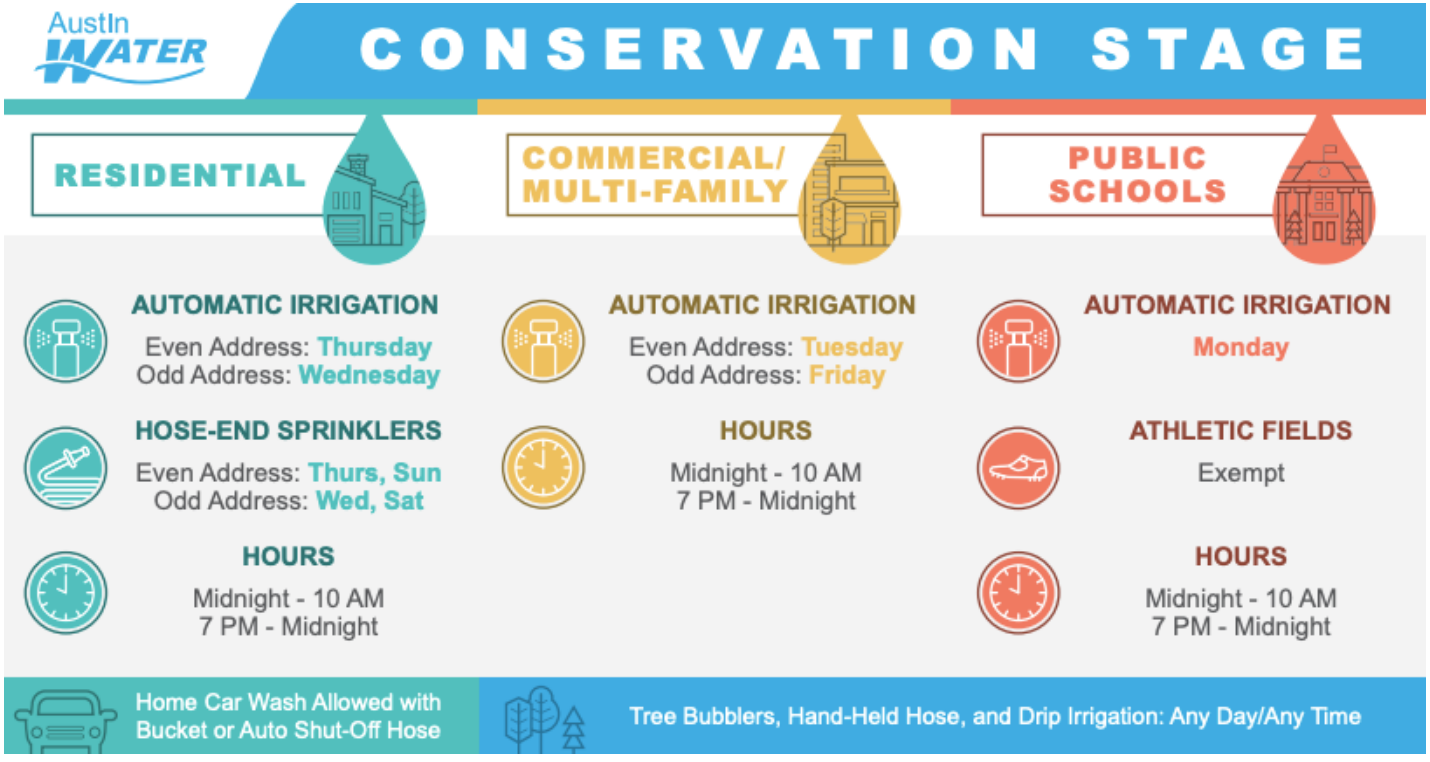
YARDI

YARDI SYSTEMS

QUESTIONS AND FEEDBACK

EXTRA SLIDE DECK

Irrigation schedule



Source: Austintexas.gov

- Entered irrigation restrictions into SUEWS status quo
- Allowed consistent irrigation across day for low, medium high
- Varied % land that is irrigated according to 25, 50, and 75% implementation levels

SOURCES OF UNCERTAINTY

SUEWS has uncertainty in:

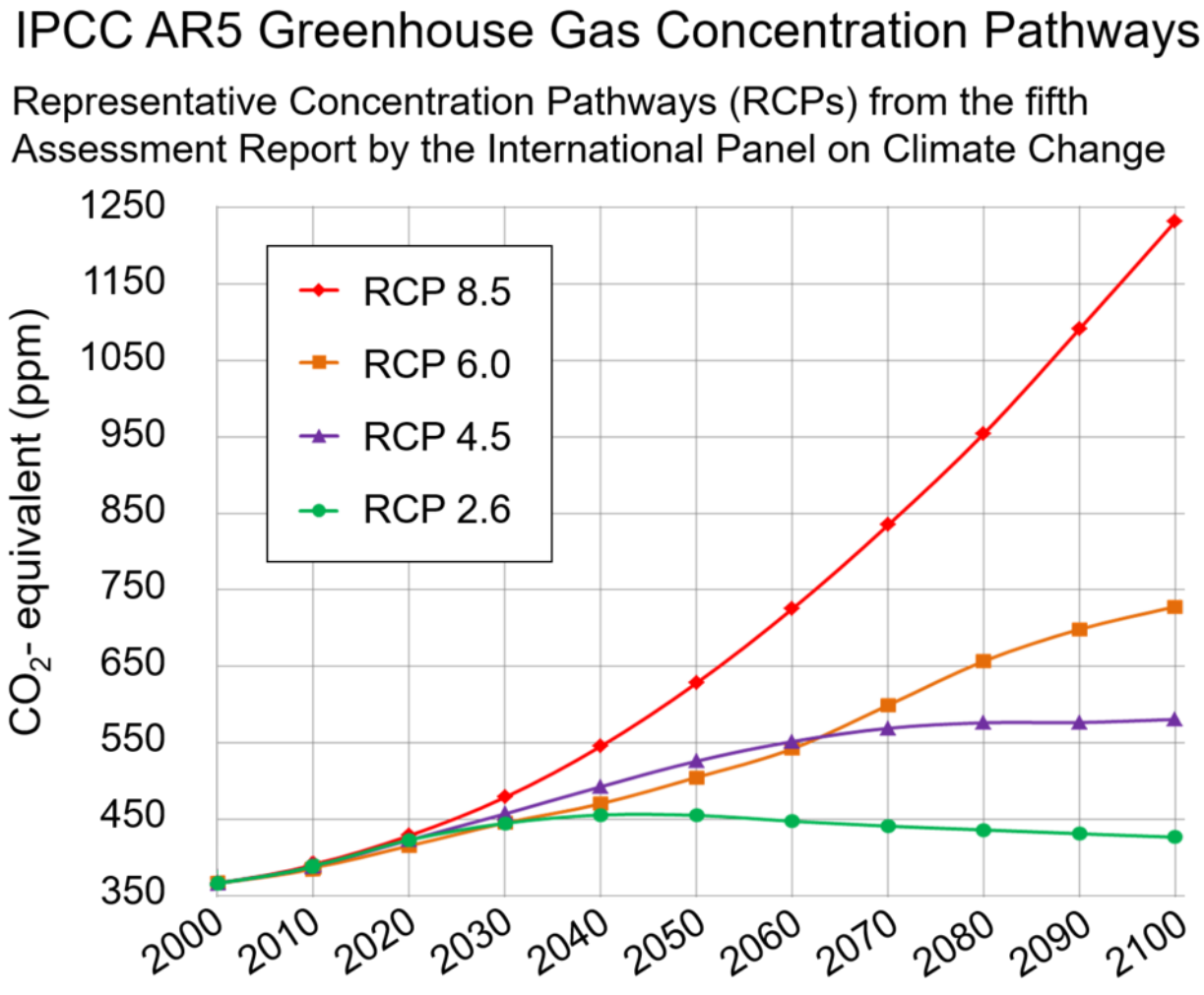
- **Variance between tree species**
- **Soil type and depth**
- **Only 2 years of met data**
- **Implementation uncertainty (design success)**
- **Irrigation behavior for individuals**

Methodology: downscaled climate data

- Multivariate Adaptive Constructed Analogs (MACA) Method for downscaling Global Climate Models (RCP 4.5)

- Representative Concentration Pathway 4.5 is a greenhouse gas trajectory that was adopted by the IPCC for its fifth Assessment Report (AR5) in 2014

- Downscaled min/max: temperature (which is what we used). Also available: relative humidity, wind speed, srad, specific humidity, and precipitation



SUEWS Model Testing

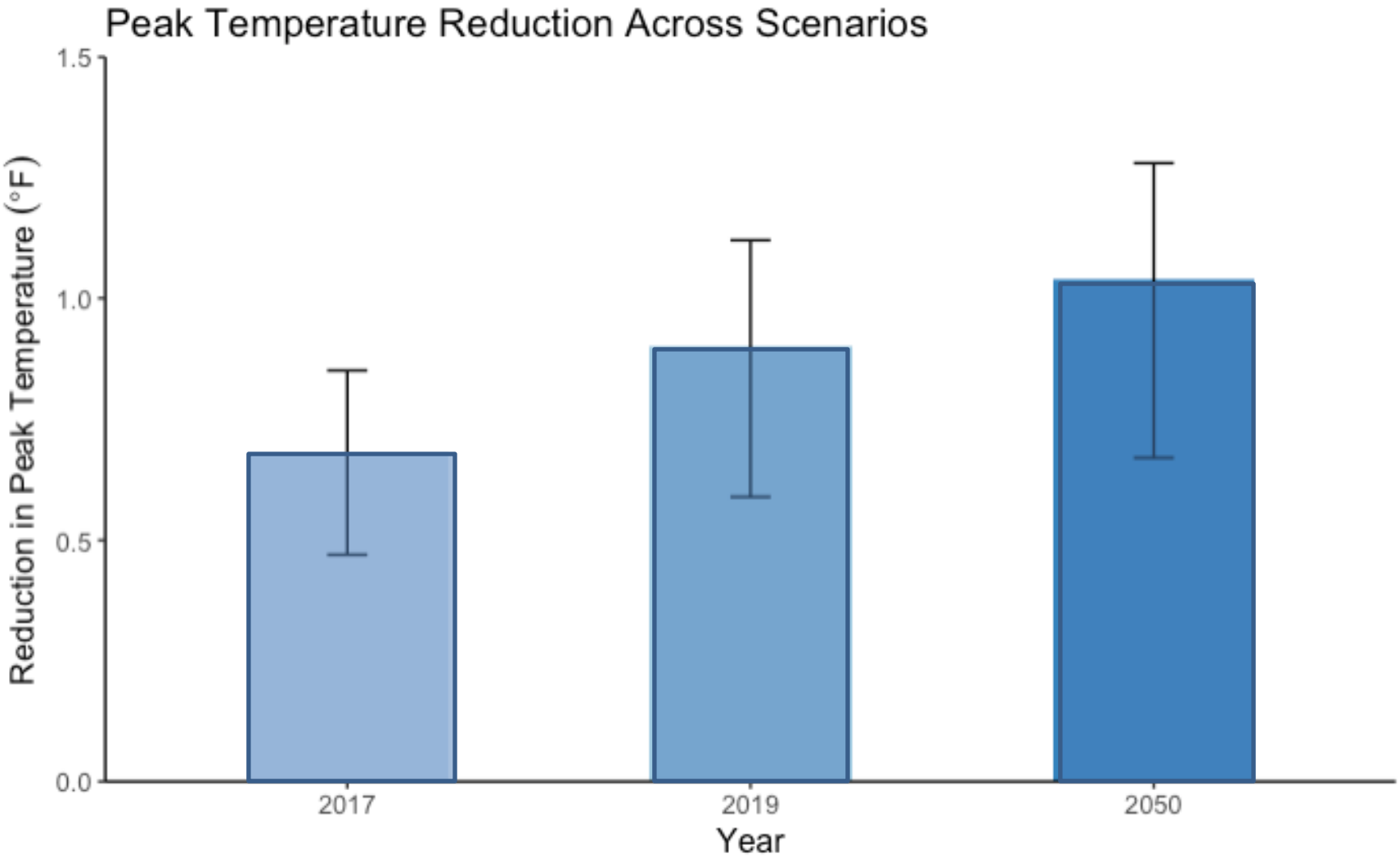
2017

	Actual temperatures (°F)	SUEWS predicted temperatures (°F)
Min	68	68.02
Mean	81.76	82.73
Median	82	82.16
Max	92.25	92.41

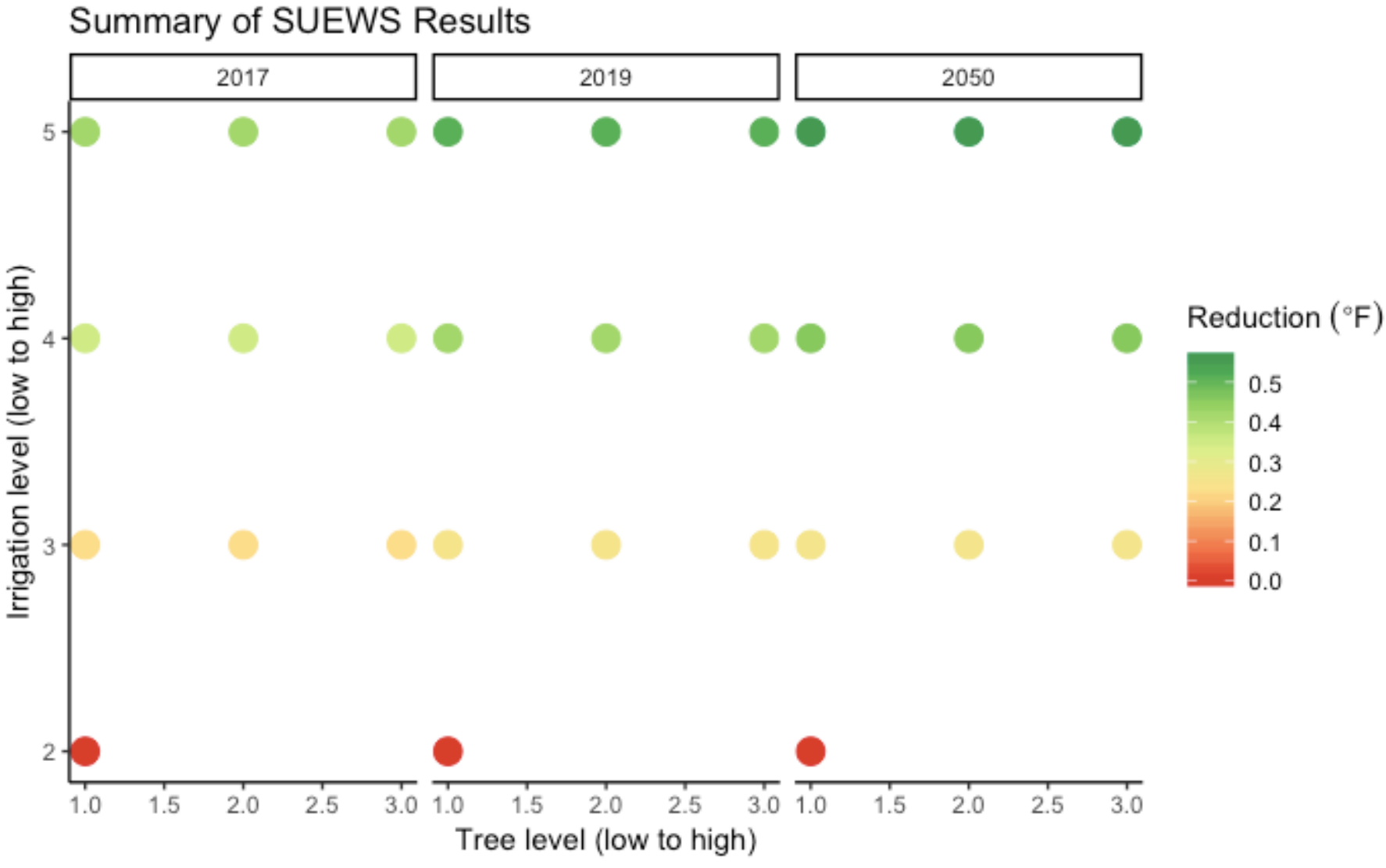
Cost of the RCPP

Average rebate is	~$2,000
Across 1200 homes	~$2,400,000
Cost to taxpayers	~$2,400,000
Total cost	~$4,800,000

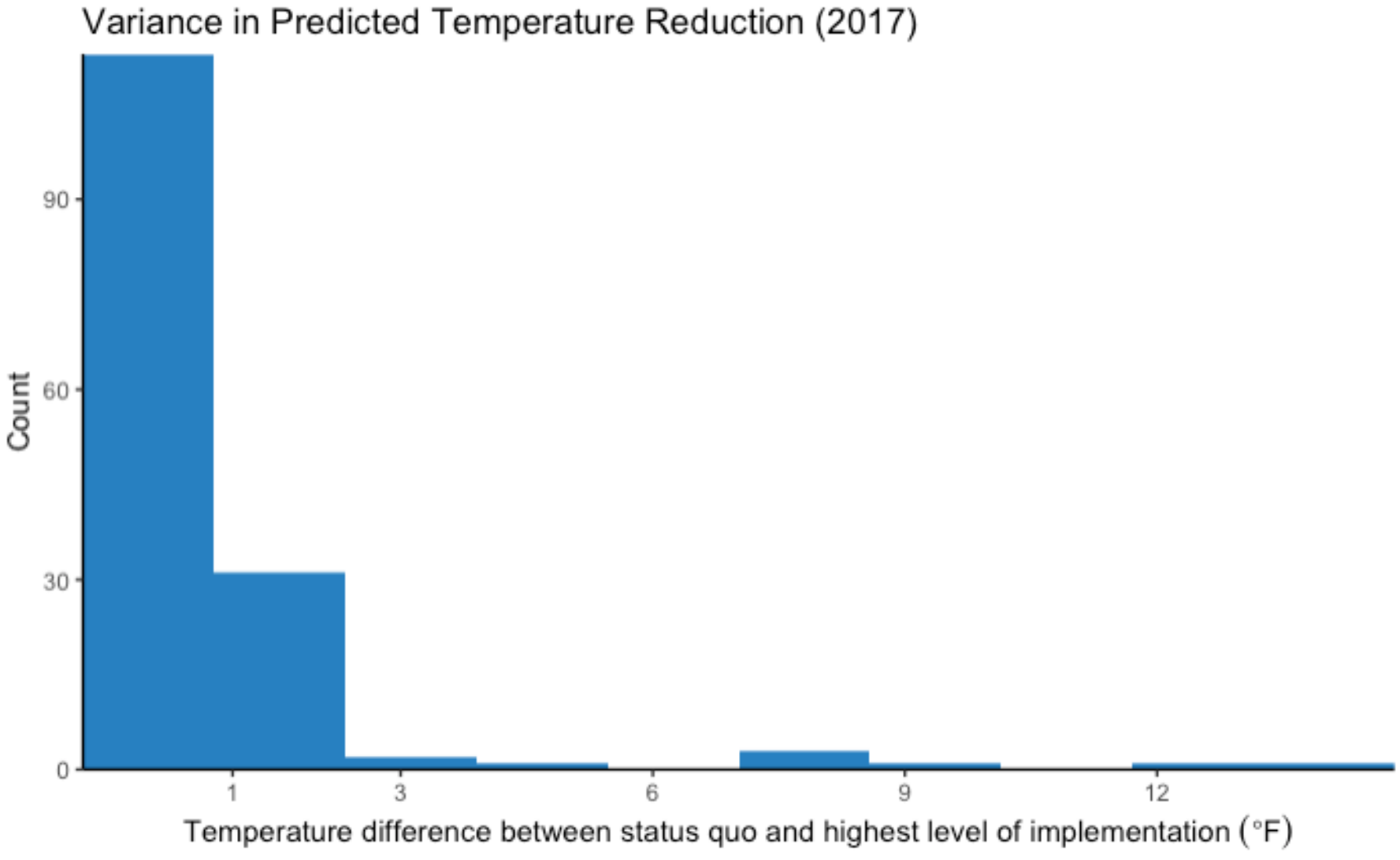
Results: High Temperatures



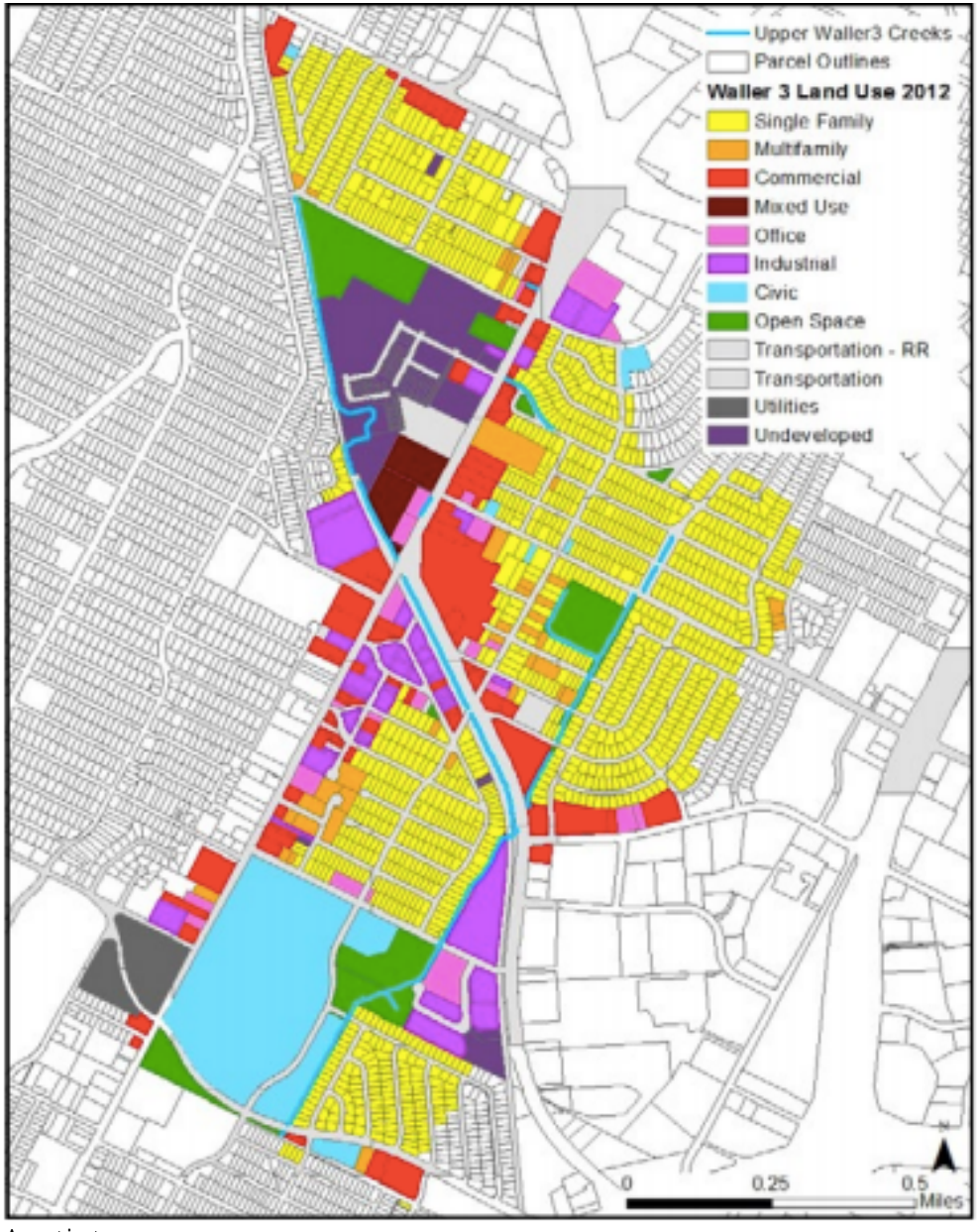
Results: Tree cover under SUEWS



Graph of High Temperature Variation



Extra info on Waller-3



Austintexas.gov

- 1 sq mile drainage