Wisconsin Initiative on Climate Change Impacts
Nelson Institute for Environmental Studies | Wisconsin Department of Natural Resources

Impacts of Climate Change on Stormwater Infrastructure Design

Rob Montgomery, PE

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Topics:

1. What's in the WICCI 2021 Assessment Report
2. Rainfall, Runoff and Drainage Infrastructure
3. Observations on Design for Future Conditions

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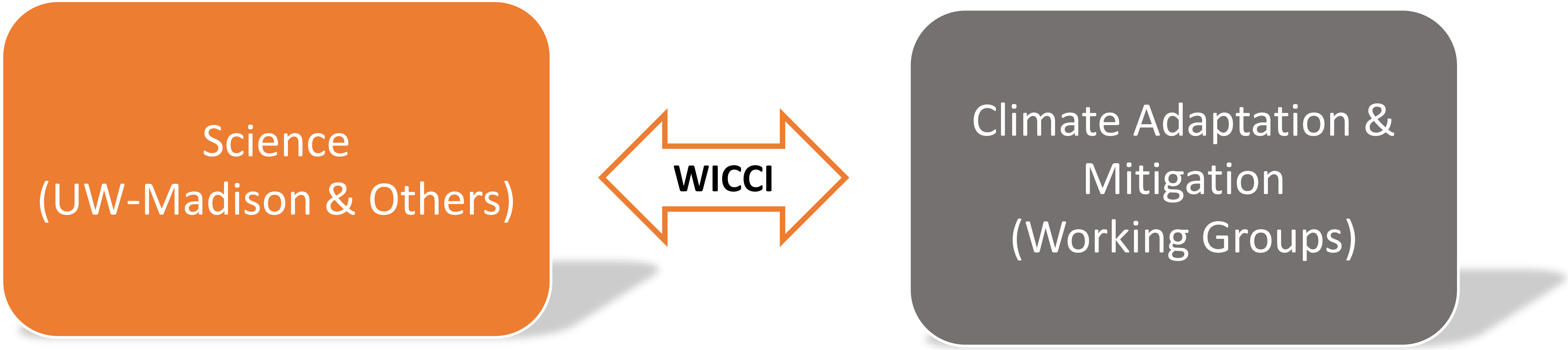
WICCI Mission



Generate and share information that can foster solutions to climate change in Wisconsin (and beyond).

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WICCI Working Groups

Air

Climate

Water

Fisheries

Great Lakes

Water Resources

Coastal Resilience

Land

Agriculture

Forestry

Natural Communities

Wildlife

Geospatial

People

Community Sustainability

Human Health

Tourism

Infrastructure

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WICCI 2021 Assessment Report

https://wicci.wiscedu/

- Update of 2011 report
- Web-based
- Lots of downloadable material
- Work ongoing, updates ongoing

Many Working Group Reports

Coastal Resilience Working Group

WICCI's Coastal Resilience Working Group uses innovative methods and technologies to describe and predict the effects that the changing climate will have on the communities and property owners of Wisconsin's coastlines.

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS / HUMAN HEALTH WORKING GROUP

Human Health Working Group

Infrastructure Working Group

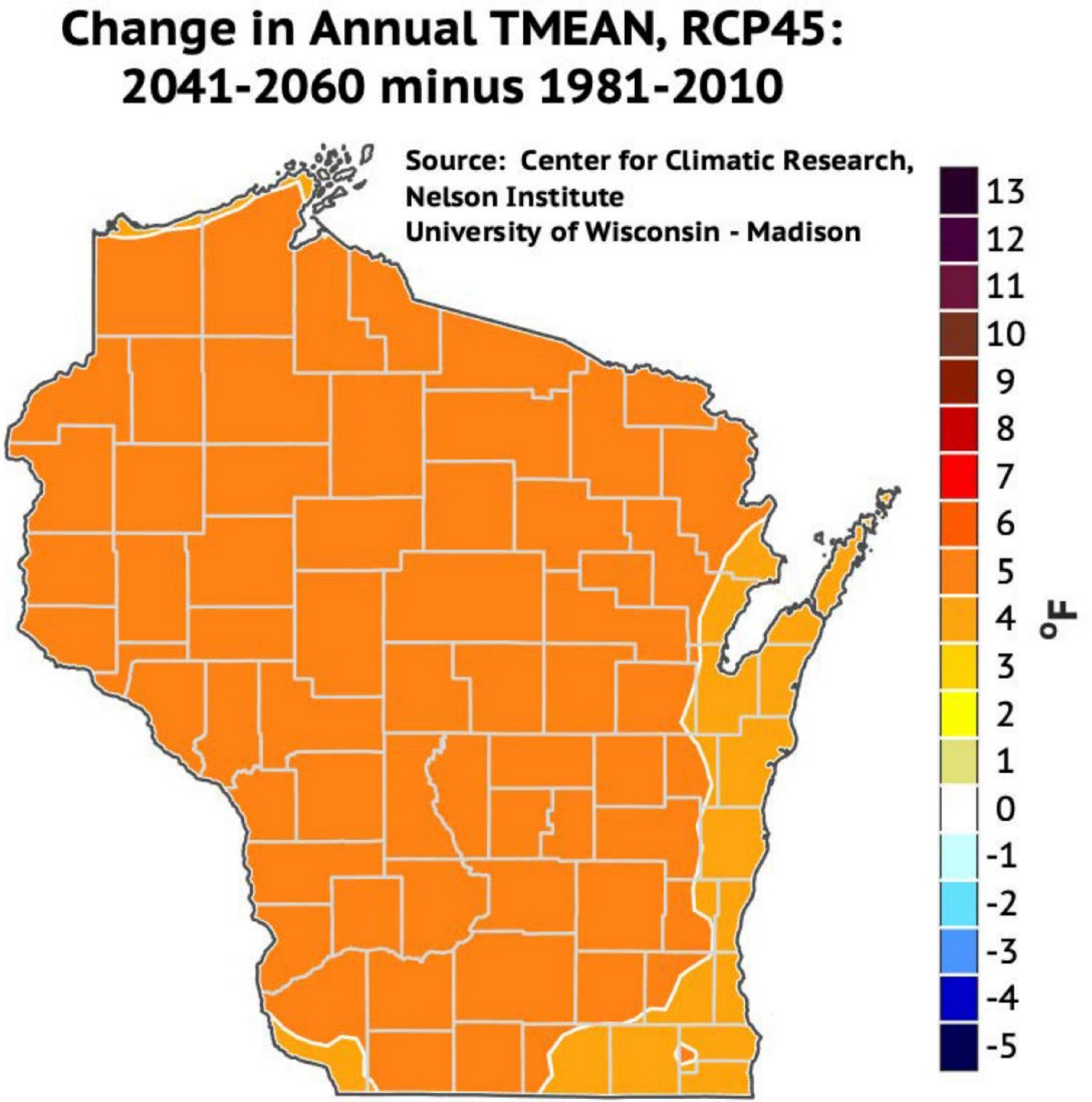
N CLIMATE CHANGE IMPACTS / AGRICULTURE WORKING GROUP

Community Sustainability Working Group

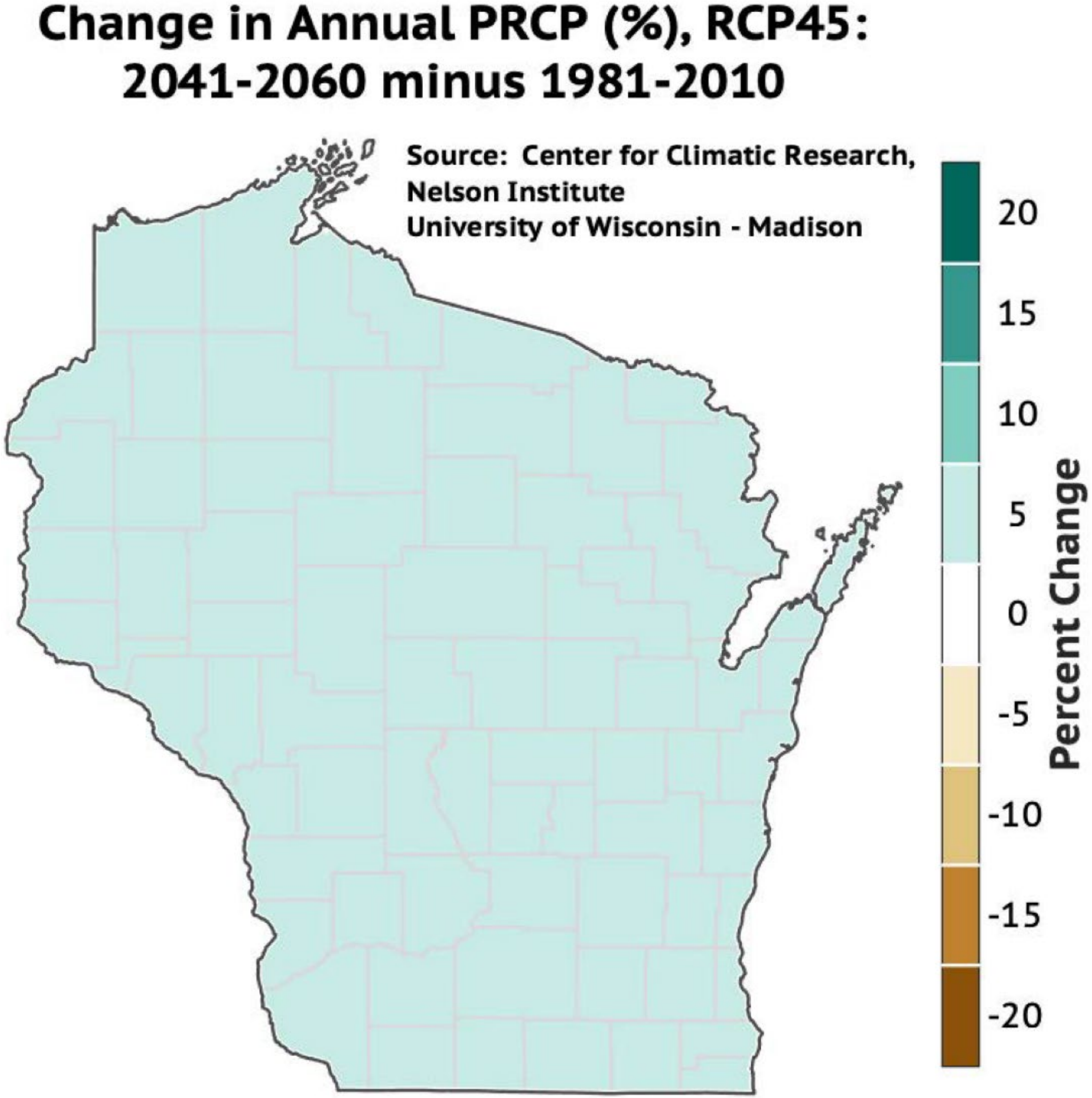
Agriculture Working Group

Climate projections on the WICCI website

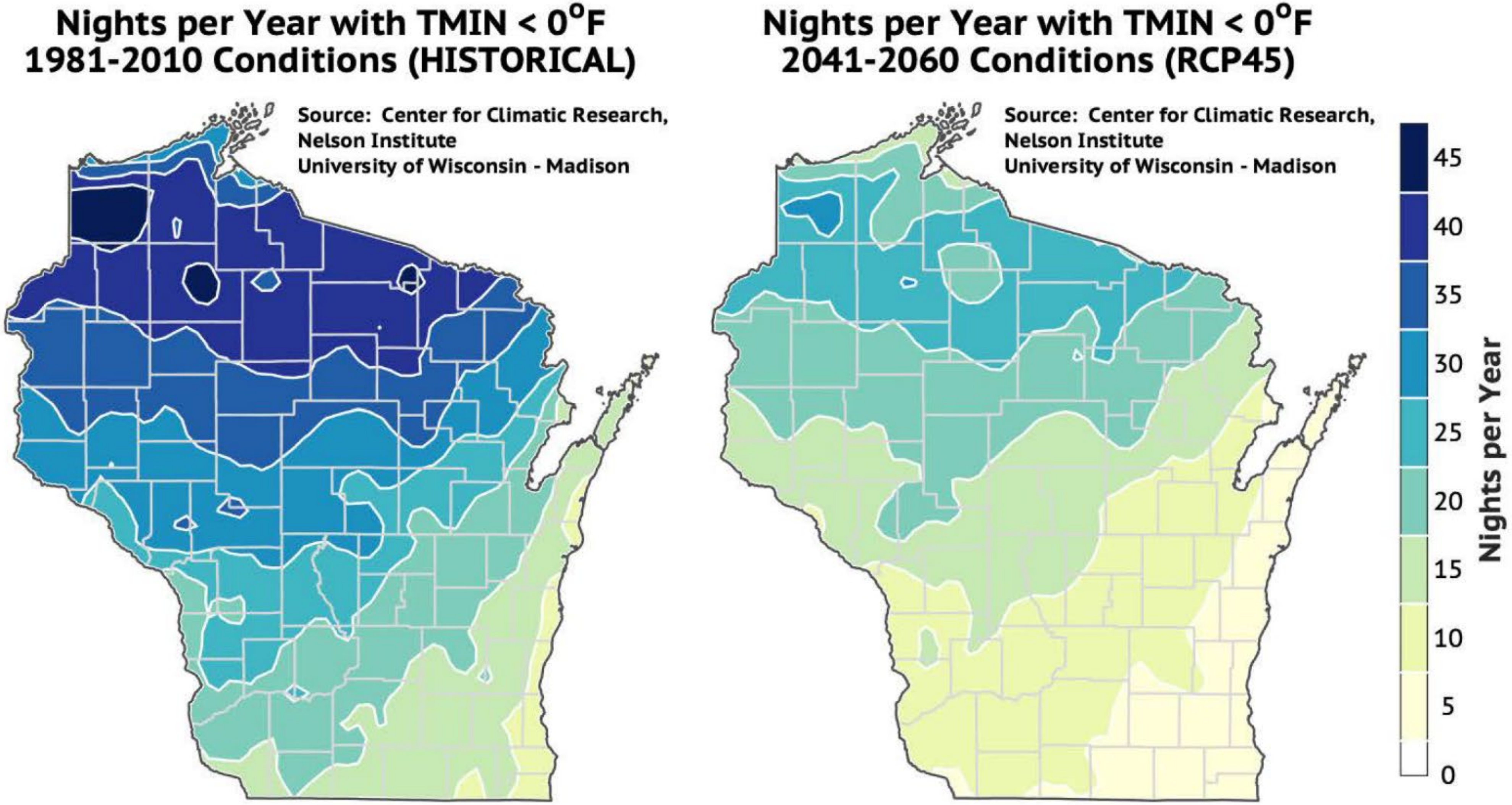
2050 average annual temperatures will be substantially warmer



And annual precipitation will be higher



Substantially fewer very cold winter nights especially in the north



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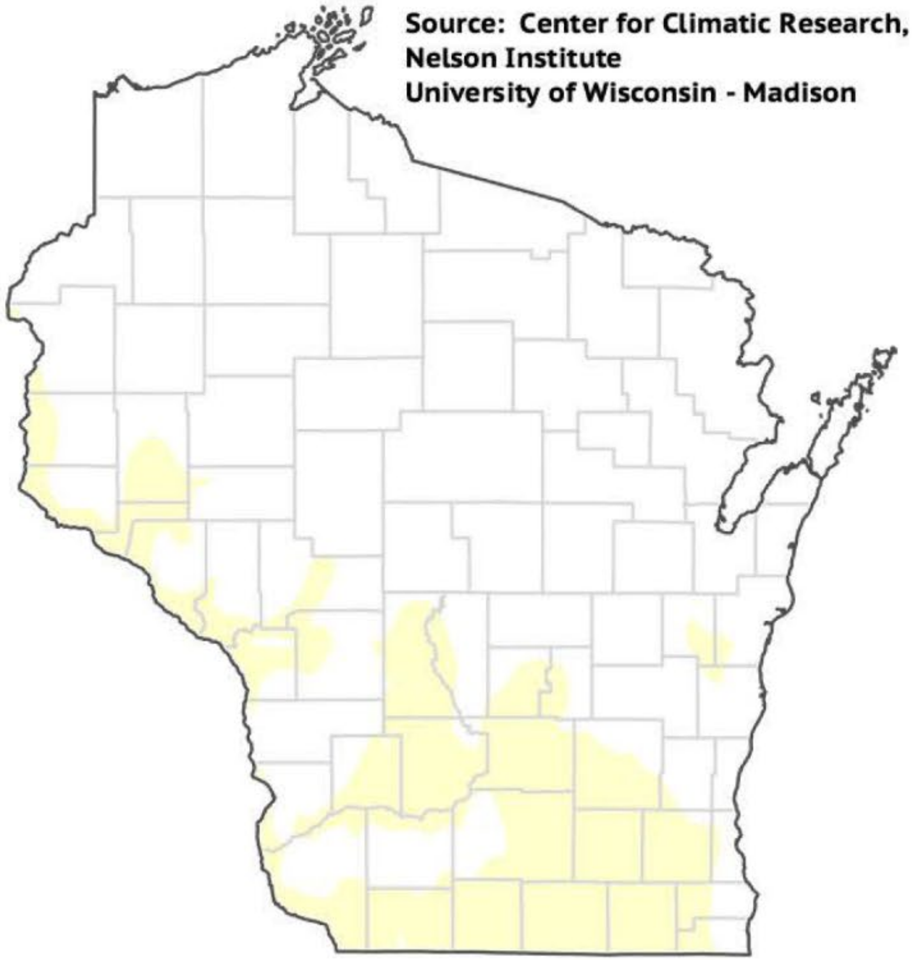
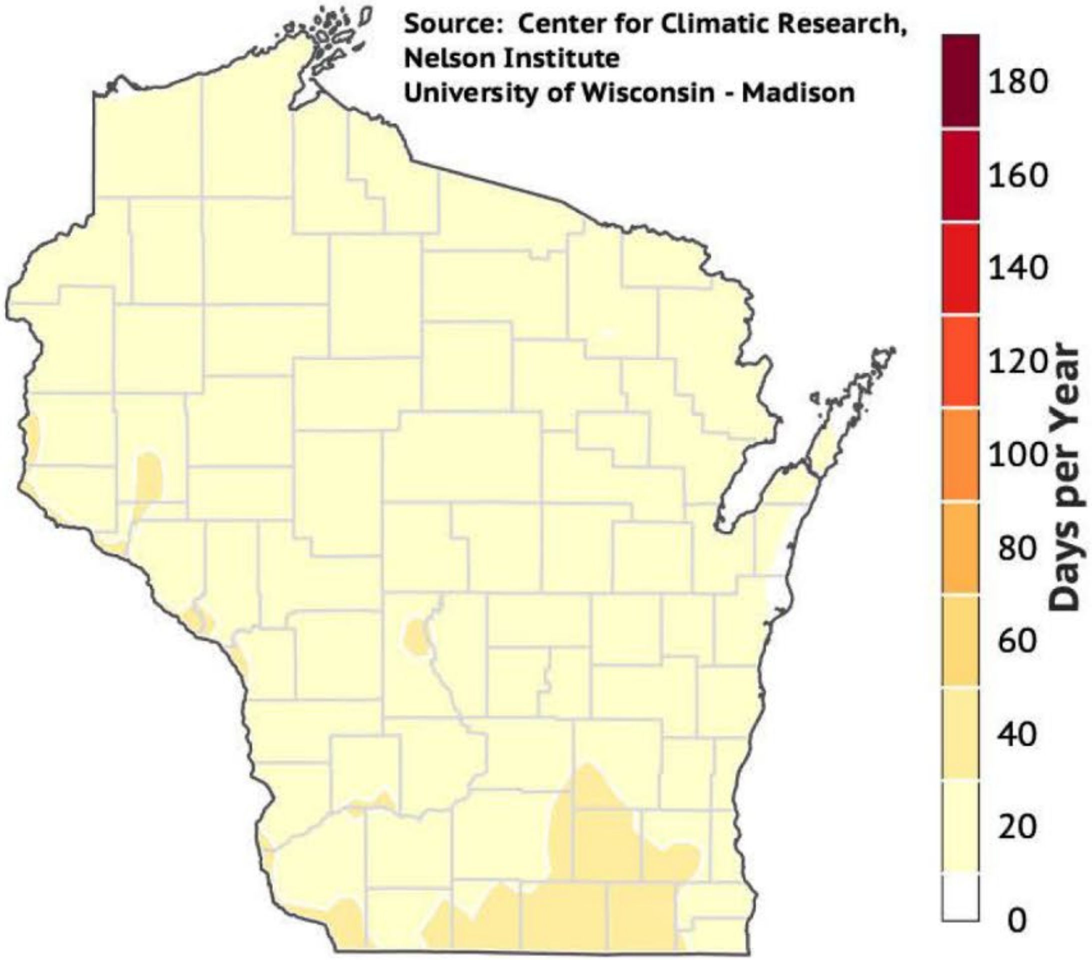
More very hot days

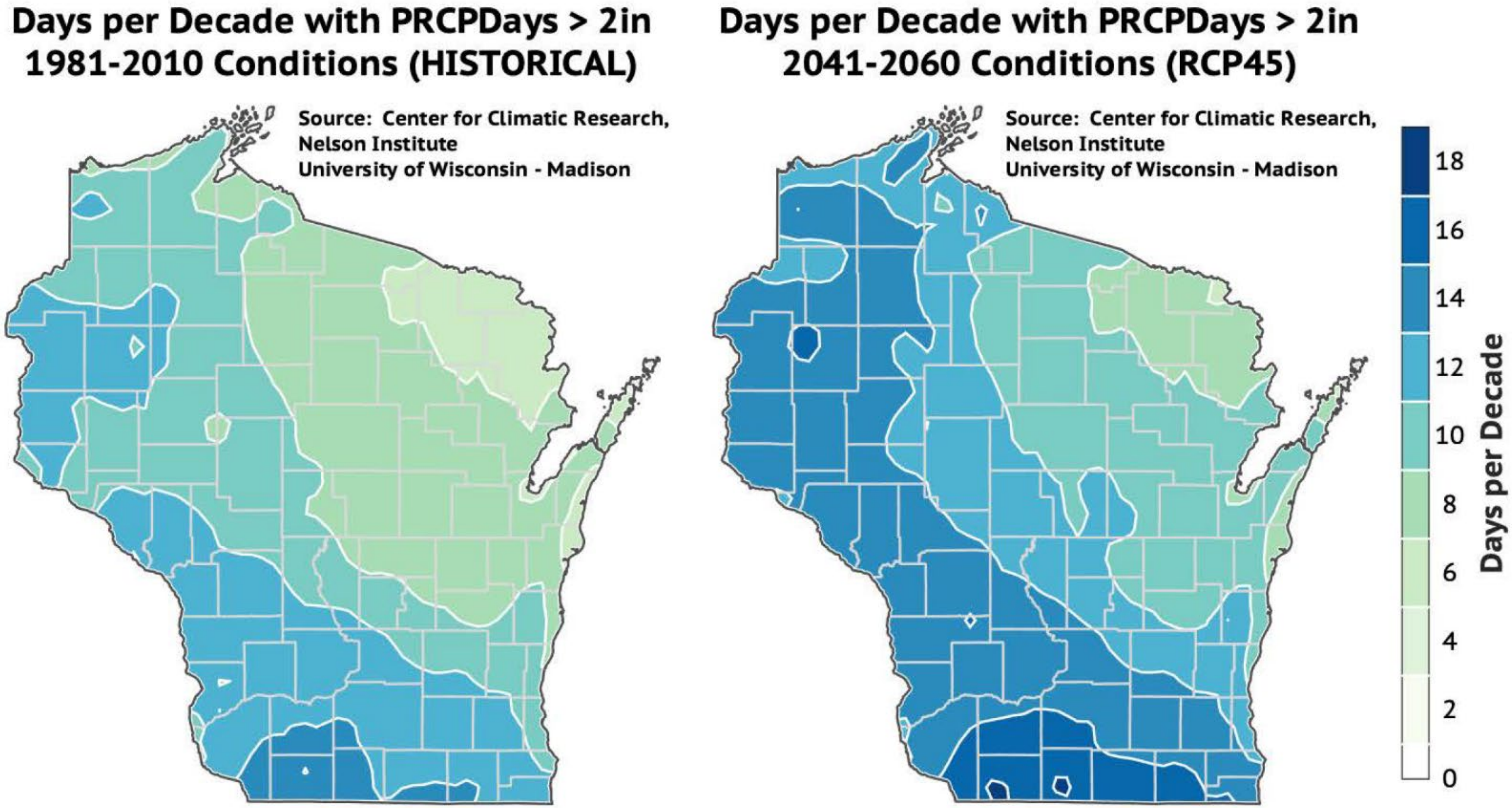
Days per Year with TMAX > 90°F
1981-2010 Conditions (HISTORICAL)



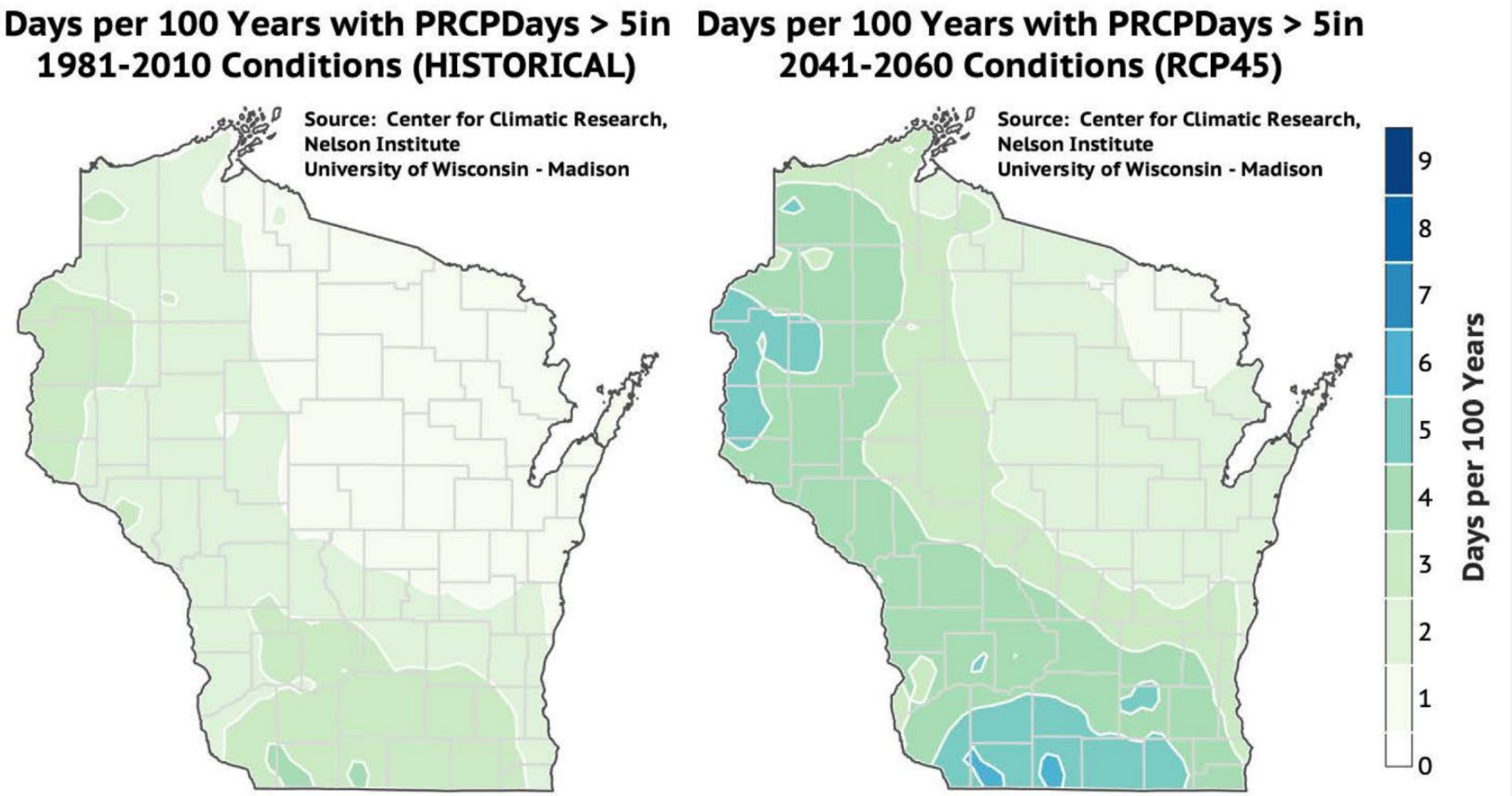
Days per Year with TMAX > 90°F
2041-2060 Conditions (RCP45)



More frequent small storms



More frequent very heavy rainfall



HYDROCLIMATE EXTREMES RESEARCH GROUP

THE WISCONSIN RAINFALL PROJECT

- Dan Wright, UW-Madison CEE
- David Lorenz, UW-Madison CCR

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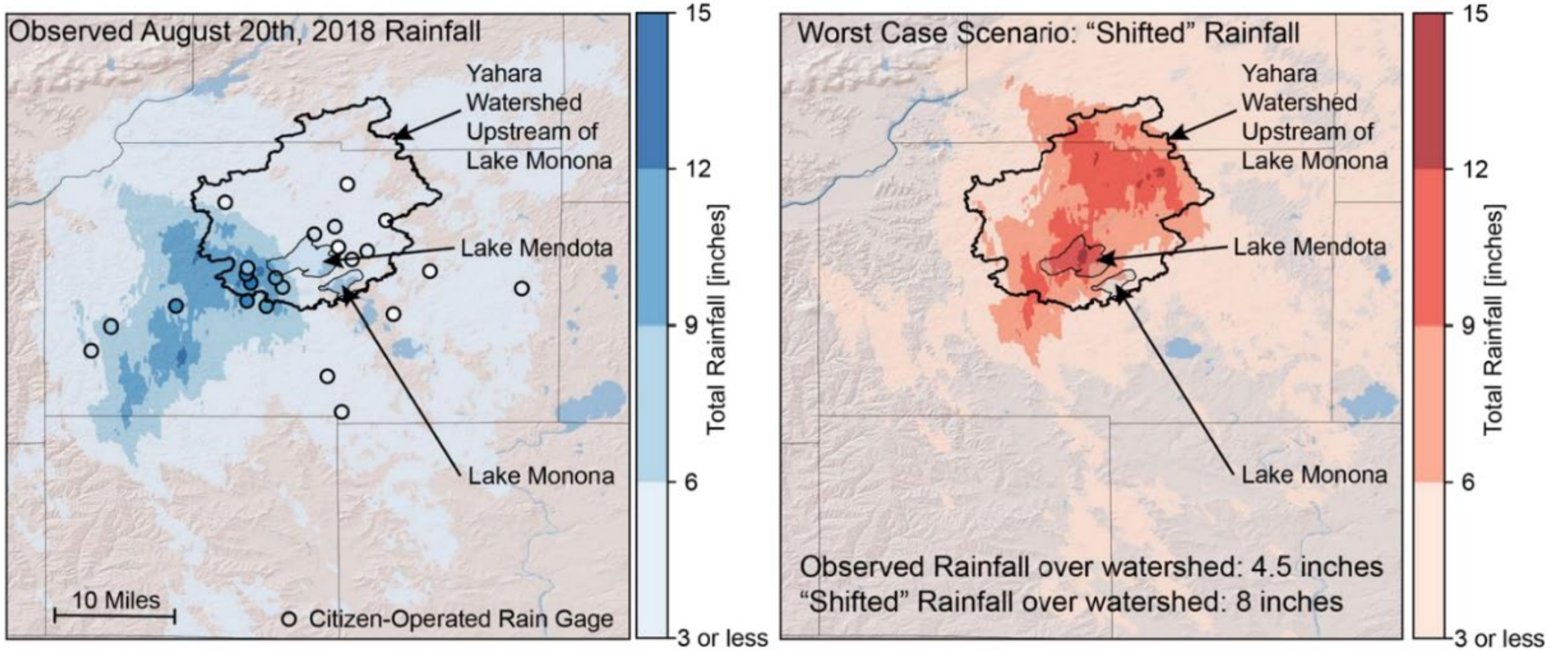
RainyDay analysis of present rainfall statistics

- Departure from rain gage analyses which are limited by gage locations and bias due to time trends in long records (“non-stationarity”)
- Uses stochastic storm transposition to create a long spatial / temporal record from 2002-2019 radar rainfall data
- IDF statistics from RainyDay are latest estimates drawn from recent data



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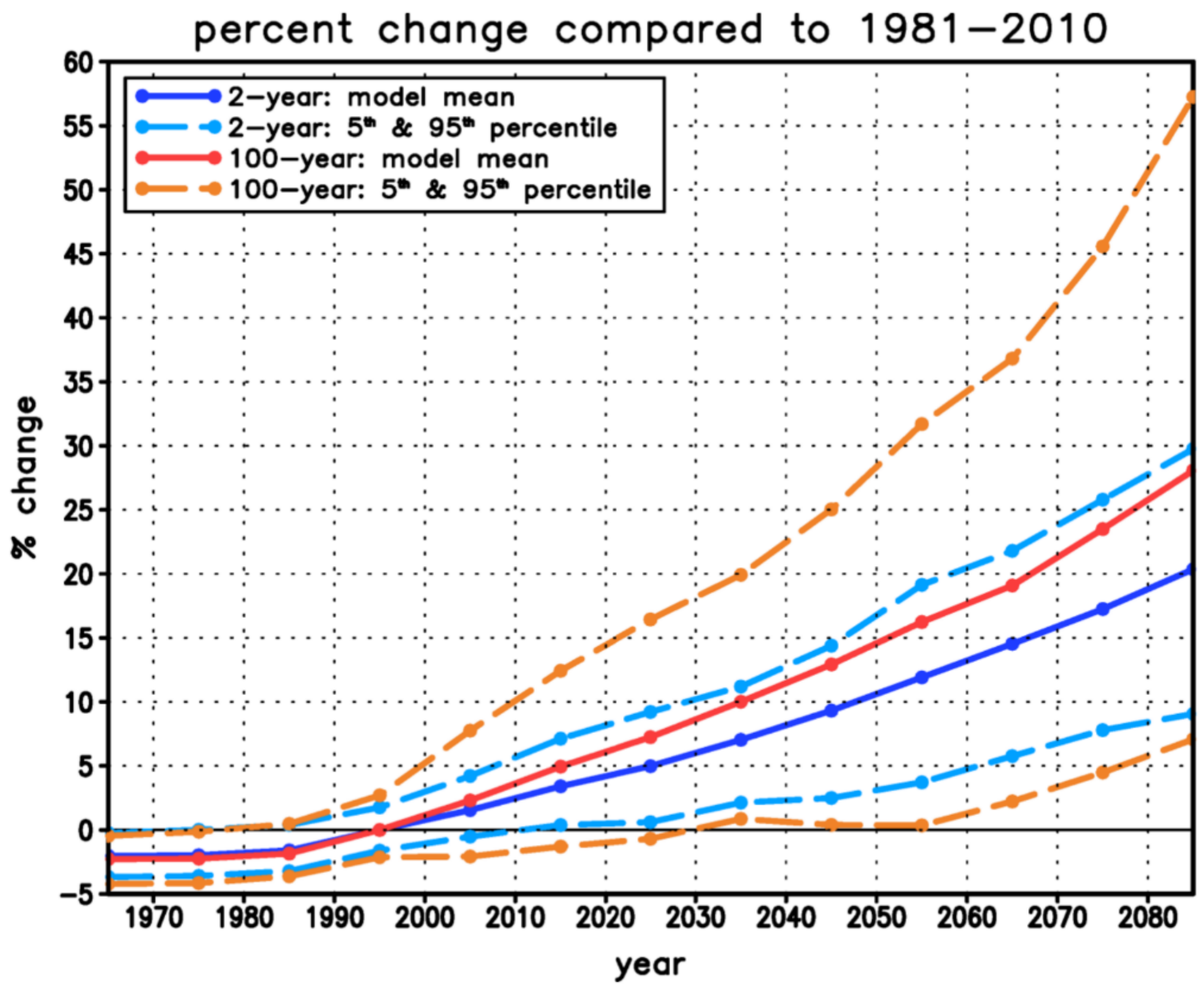
Future climate rainfall statistics using UW Probabilistic Downscaling

- Statistics to year 2100 generated from 22 CMIP5 climate models using University of Wisconsin Probabilistic Downscaling (UWPD) dataset
- Extreme rainfall depths increase for all return periods and greenhouse gas scenarios (RCP 4.5 & 8.5)
- Analyses out to year 2100
- 24-hr limitation due to CIMP5 model time step



Rainfall Data available in Portal: Atlas 14 10-Year

- County-by-County data display

Choose a duration (24-hour only for climate projections):

24 hours

Choose a recurrence interval:

10-year

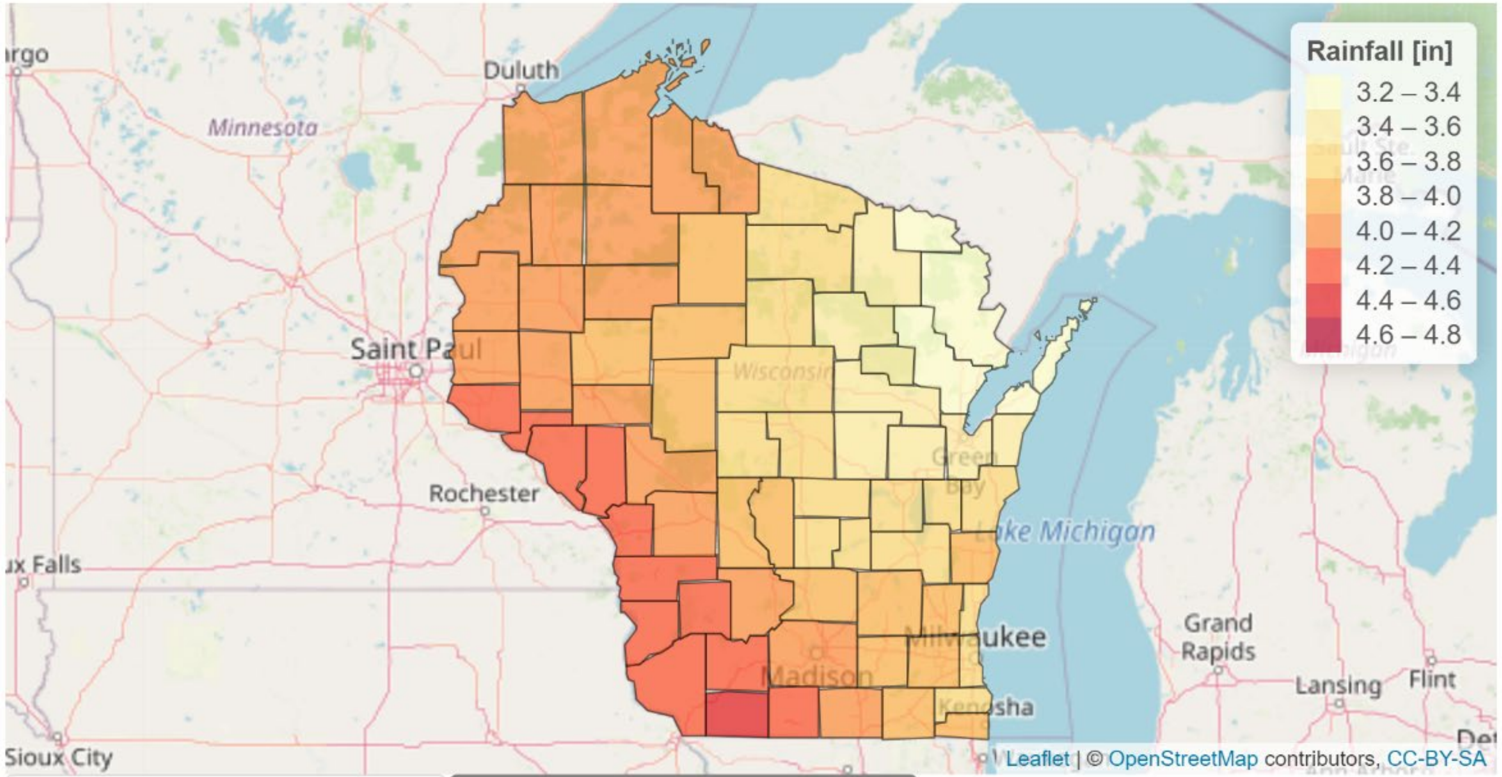
Choose a unit type:

in (depth)

Choose a data source:

Present Conditions- NOAA Atlas 14

Click on a Wisconsin county in the map for more detailed results



Precipitation Frequency Tabular | Precipitation Frequency Graphical

Data Table | Download Table

Present Conditions – Rainy Day 10-Year

- Analysis software available

Choose a duration (24-hour only for climate projections):

24 hours

Choose a recurrence interval:

10-year

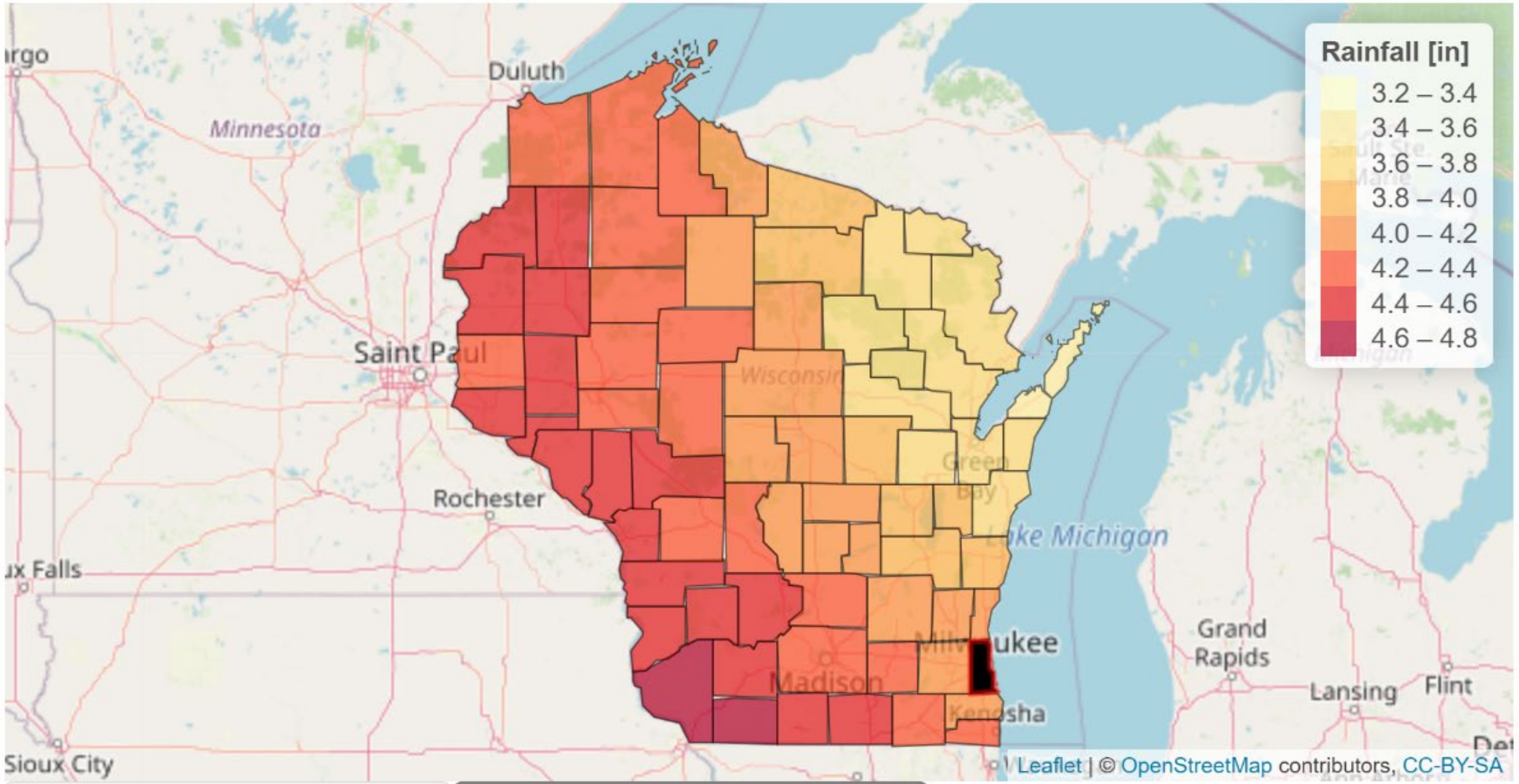
Choose a unit type:

in (depth)

Choose a data source:

Present Conditions- RainyDay

Click on a Wisconsin county in the map for more detailed results



Precipitation Frequency Tabular | Precipitation Frequency Graphical

Data Table | Download Table

Comparison between Rainy Day and Atlas 14

- Difference varies by location and return period

Choose a duration (24-hour only for climate projections):

24 hours

Choose a recurrence interval:

10-year

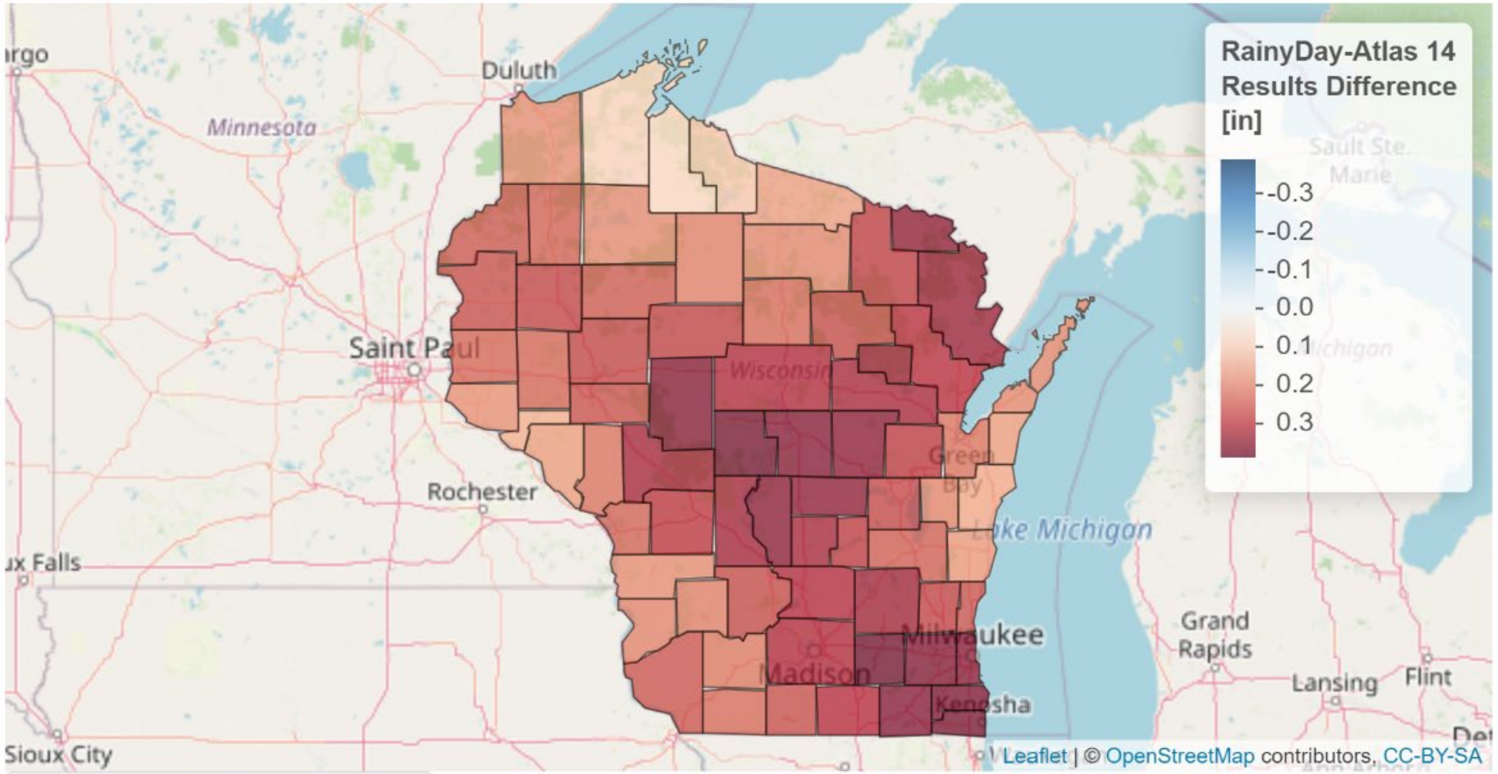
Choose a unit type:

in (depth)

Choose a data source:

Present Conditions- RainyDay-Atlas 14 Comparison

Click on a Wisconsin county in the map for more detailed results



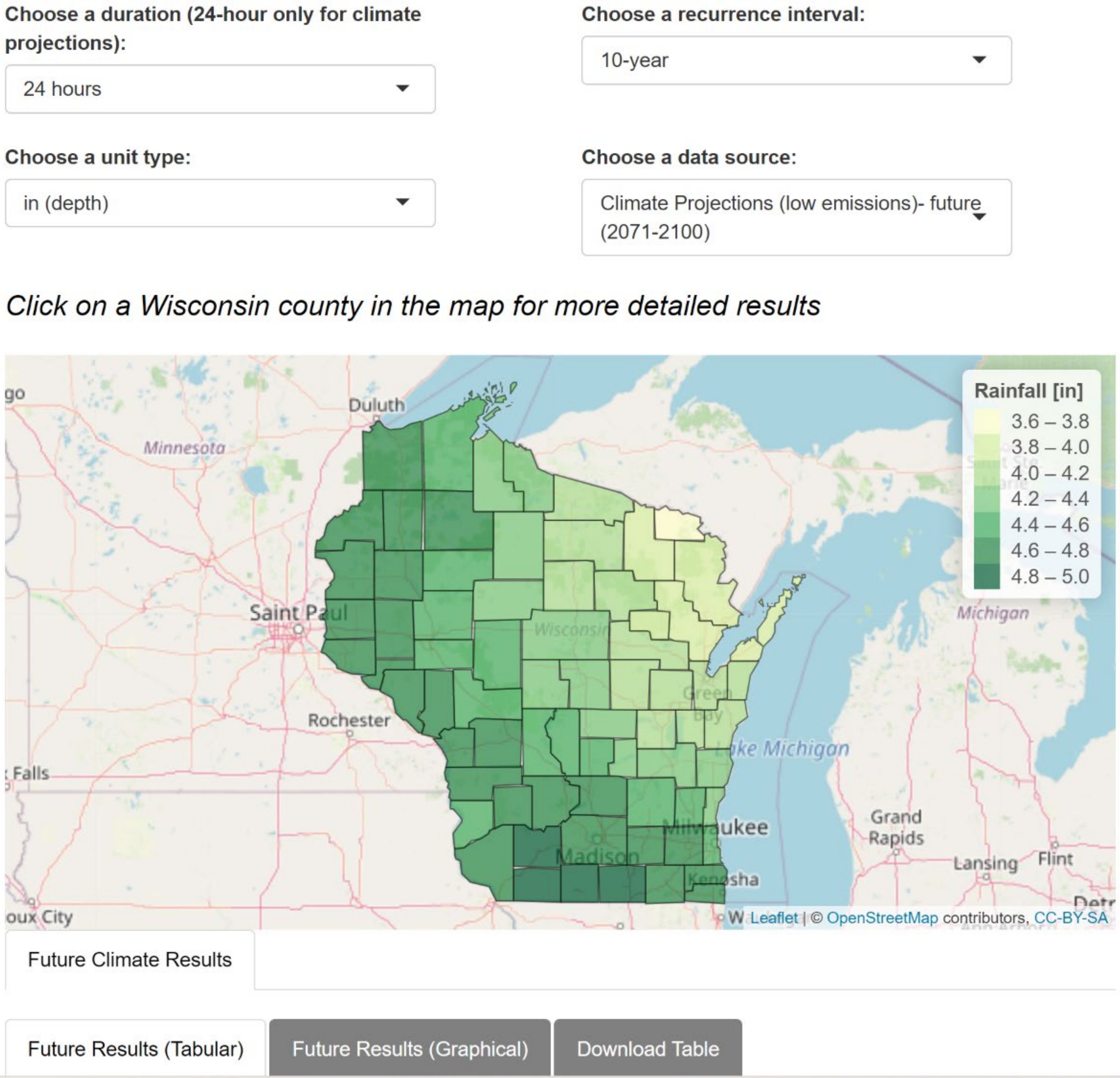
RainyDay-Atlas14 Comparison

Comparison Data Table

Download Table

2071-2100
GHG Scenario 4.5

- 2041-2070 also available
- 24 hr duration only



2071-2100
GHG Scenario 8.5

- More significant increases at more extreme events
- More significant increases farther into the future

Choose a duration (24-hour only for climate projections):

24 hours

Choose a recurrence interval:

10-year

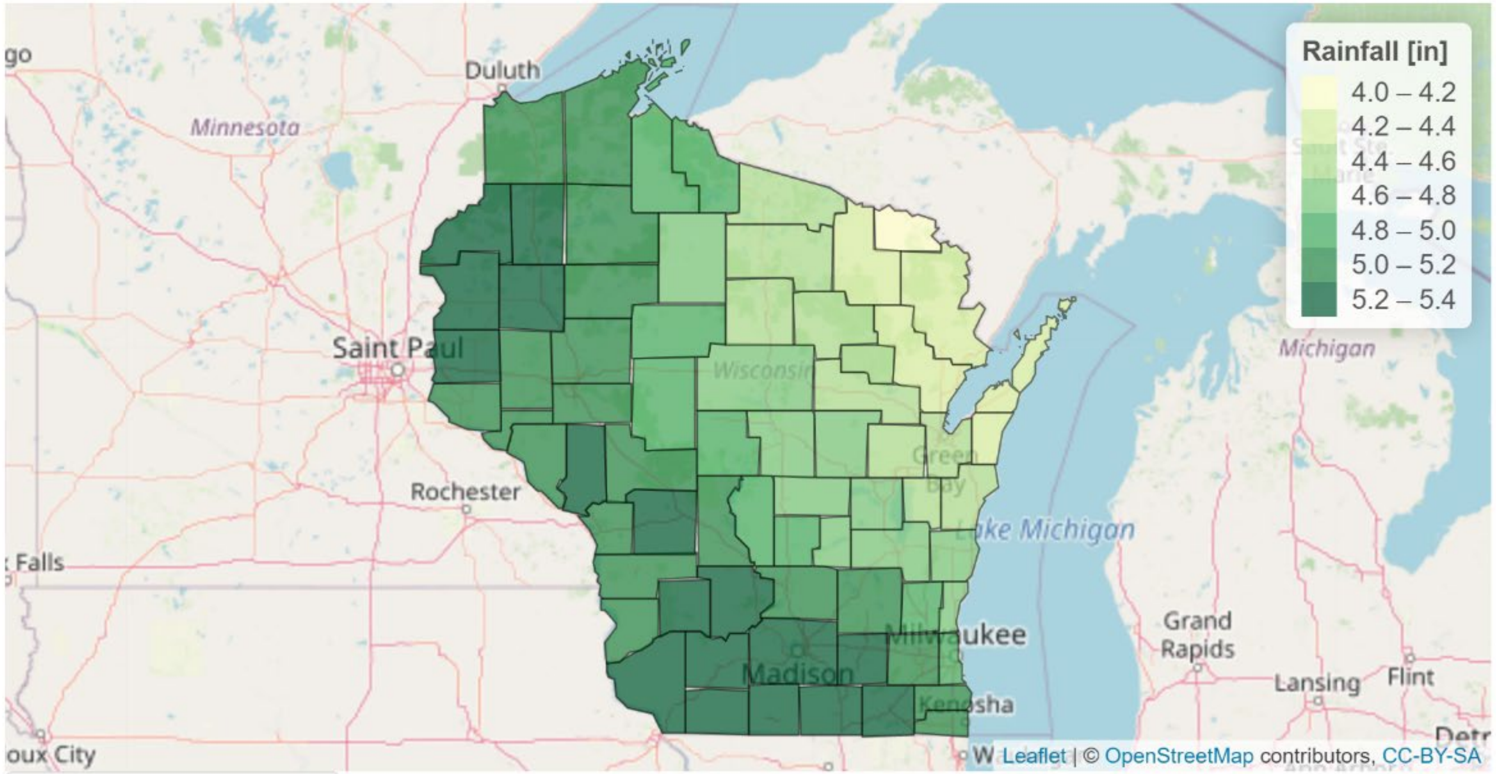
Choose a unit type:

in (depth)

Choose a data source:

Climate Projections (high emissions)- future (2071-2100)

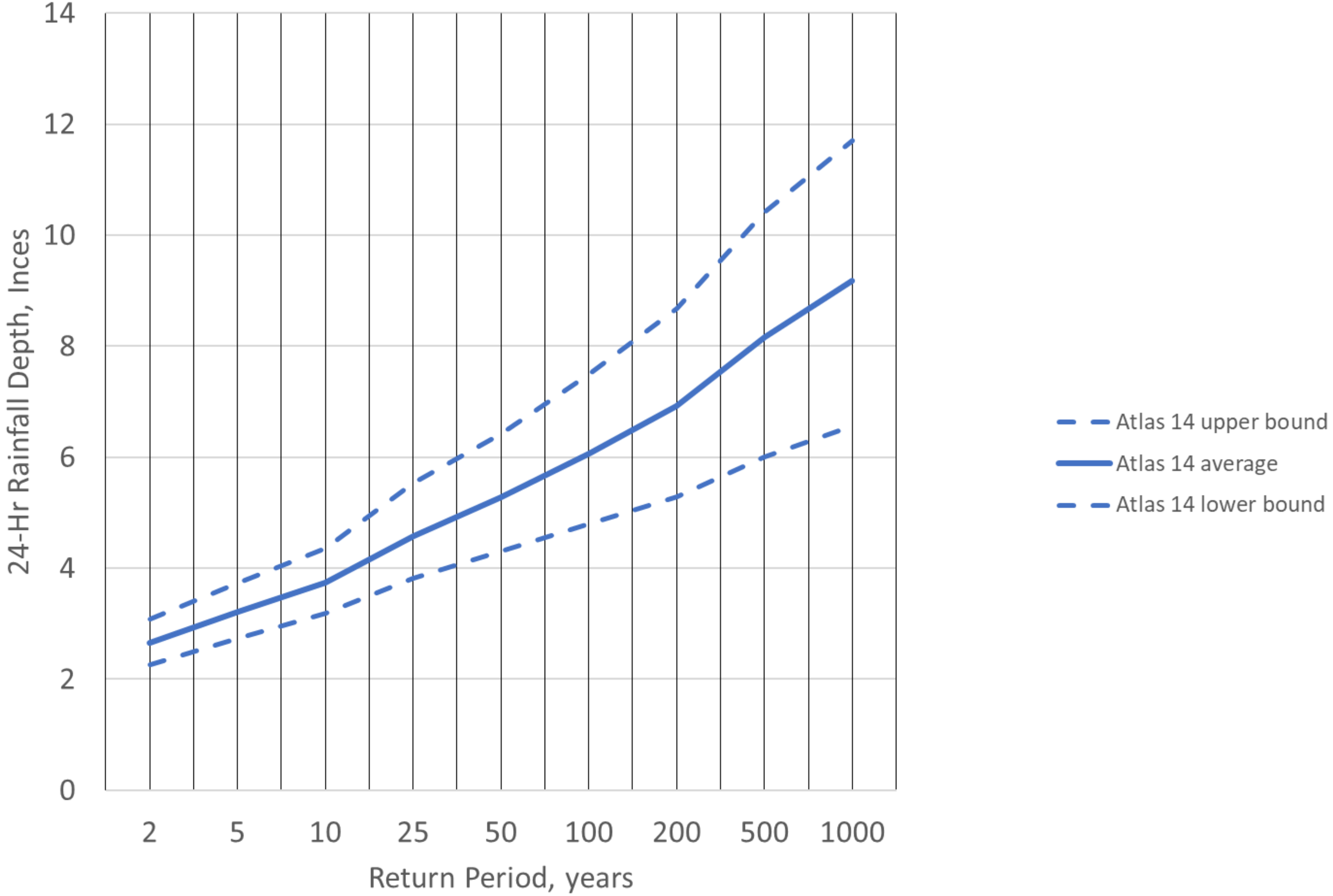
Click on a Wisconsin county in the map for more detailed results



Future Climate Results

Future Results (Tabular) | Future Results (Graphical) | Download Table

Atlas 14 Rainfall for Milwaukee County



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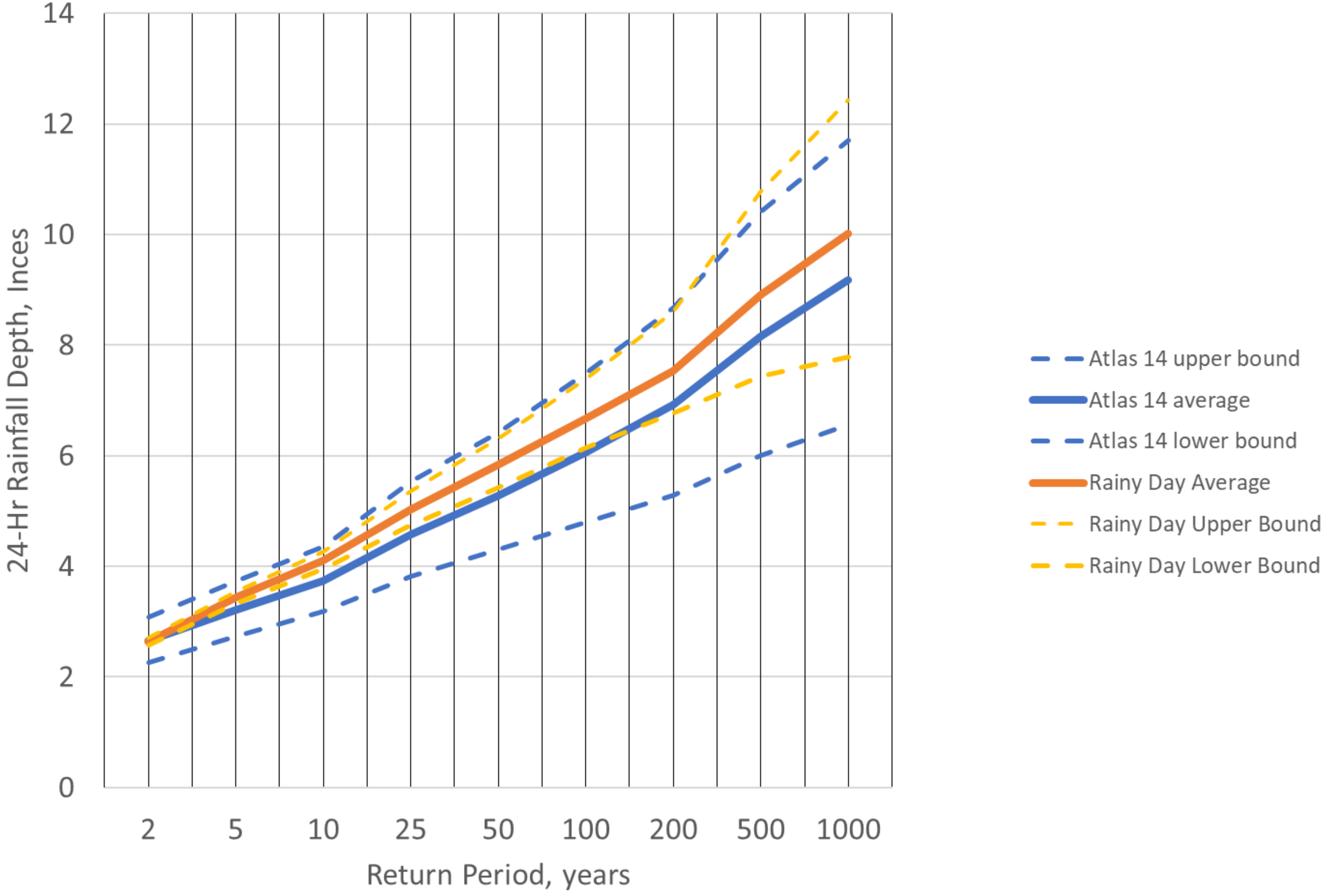
Atlas 14 & Rainy Day Rainfall for Milwaukee County



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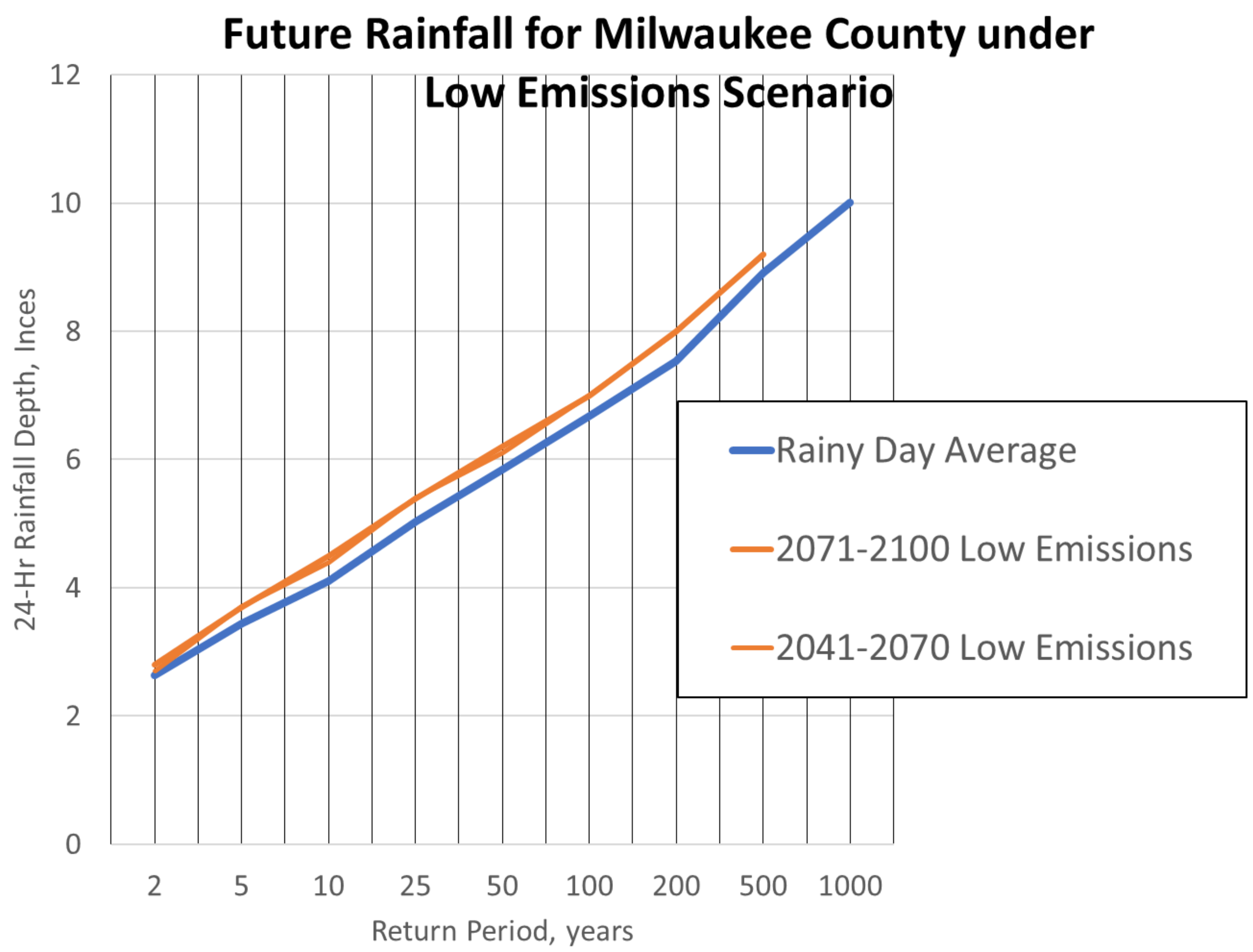

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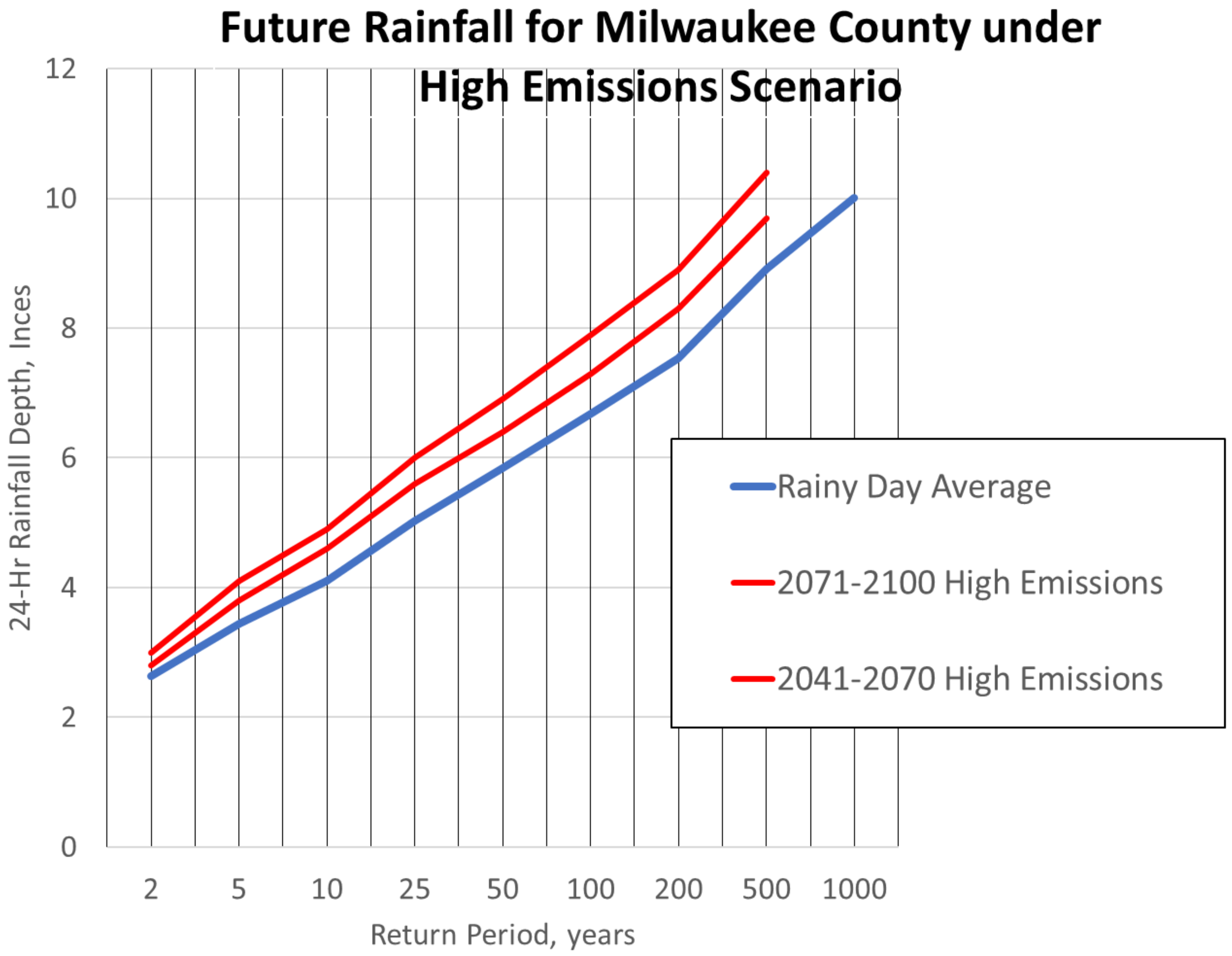
Future Rainfall for Milwaukee County under High Emissions Scenario
24-Hr Rainfall Depth, Inces
0
2
4
6
8
10
12
2
5
10
25
50
100
200
500
1000
Return Period, years
Rainy Day Average
2071-2100 High Emissions
2041-2070 High Emissions
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How significant is future conditions rainfall in drainage infrastructure design?

1. SEMCOG Study
2. Milwaukee County

Developing Regional Solutions

SEMCOG

Southeast Michigan Council of Governments

Climate Data by Tetra Tech

Hydraulic and Cost analysis by HRC Engineering

Current 10-year Rainfall Event

Existing 10-acre Project in SE Michigan by HRC Engineering

- Rainfall 10yr- 24hr: 3.52 in (Bulletin 71)

- Total project cost for Installing new storm sewer pipe is $1.39M.

Year 2100 10-year Rainfall Event

- Rainfall 10yr- 24hr: 5.37 in (Statistical Downscale of RCMs for RCP 8.5 by Tetra Tech)

- Total project cost for Installing new storm sewer pipe is $1.47M.

Analysis Results

Road drainage area: 10 ac
Rational method

Current Condition :

- Rainfall Depth: 3.52 in
- South Branch 11.5 cfs
- North Branch 3.2 cfs

Year 2100 Future Condition:

- Rainfall Depth: 5.37 in
- South Branch 16.0 cfs
- North Branch 4.3 cfs

Summary:

- Example analysis - preliminary
- Rainfall increased by +1.85 in
- The peak flow increased by approximately 40%.
- Total project cost increased by approximately 6%.
- This is a Storm Sewer only project- cost increases for detention or pumping would be more significant

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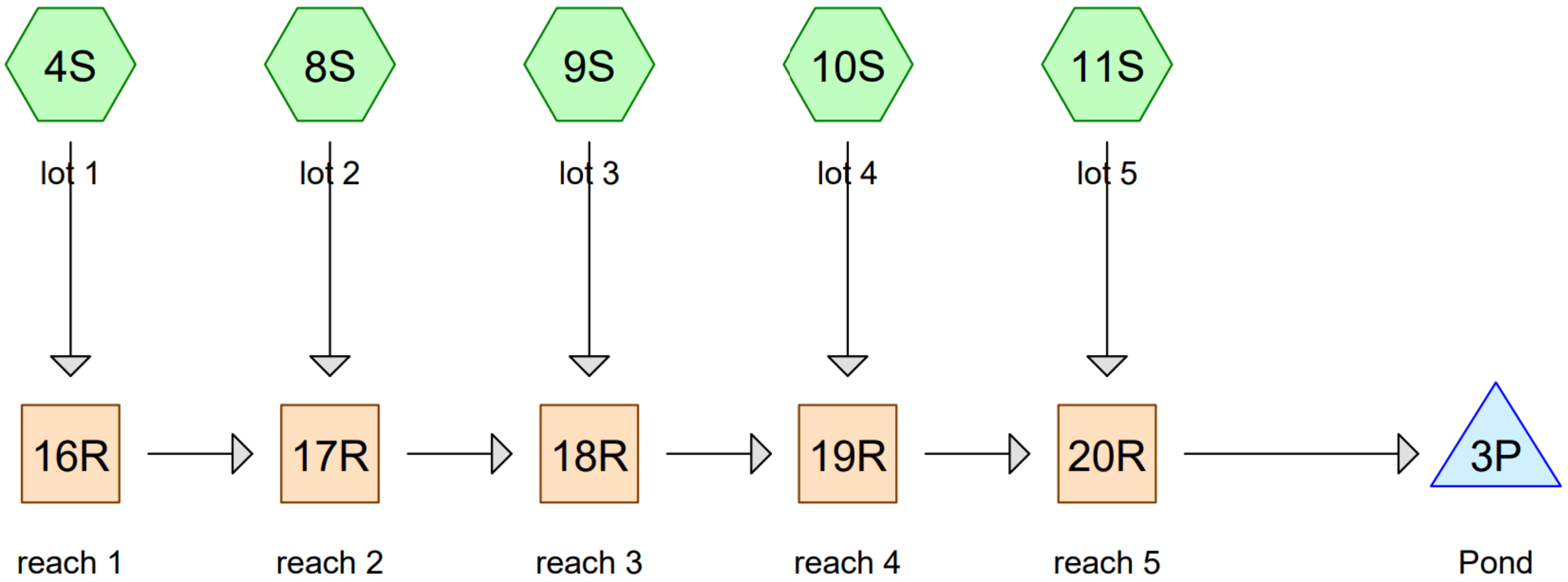
Significance in Milwaukee County

- 10-year 24 hr storm depth for Mil. Co. using MSE 3 in HydroCad
- 5 Impervious areas, 2 acres each, CN 98, Tc 6 min
- Detention basin with specified release 0.3 cfs/ac.



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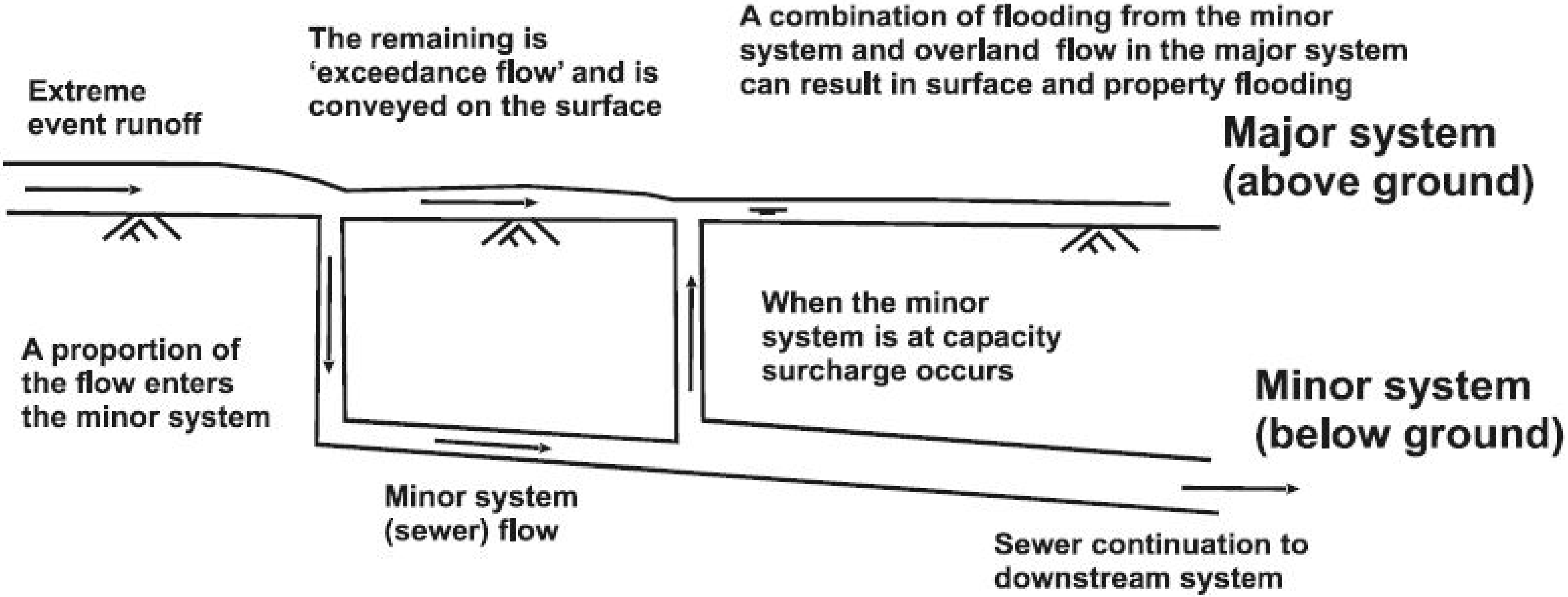
Minor and Major Drainage Systems



Results for 10-acre impervious watershed Comparison 1: Atlas 14 v RainyDay 10-yr

Event	Depth	Max Discharge, cfs	Runoff Volume, af	Storage for 3 CFS
Atlas 14 10-yr	3.75	52	2.9	1.4
Atlas 14 100-yr	6.06	85	4.8	2.7
RainyDay 10-yr	4.10	57	3.2	1.6
RainyDay 100-yr	6.68	94	5.4	3.1
2100 HI 5–yr	4.10	57	3.2	1.6
2100 HI 10-yr	4.90	68	3.9	2.1
2100 HI 100-year	7.90	111	6.3	3.8

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Results for 10-acre impervious watershed Comparison 2: Atlas 14 v 2100 10-yr

Event	Depth	Max Discharge, cfs	Runoff Volume, af	Storage for 3 CFS
Atlas 14 10-yr	3.75	52	2.9	1.4
Atlas 14 100-yr	6.06	85	4.8	2.7
RainyDay 10-yr	4.10	57	3.2	1.6
RainyDay 100-yr	6.68	94	5.4	3.1
2100 5–yr	4.10	57	3.2	1.6
2100 10-yr	4.90	68	3.9	2.1
2100 100-year	7.90	111	6.3	3.8

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Results for 10 acre impervious area watershed Comparison 3: 100-yr

Event	Depth	Max Discharge, cfs	Runoff Volume, af	Storage for 3 CFS
Atlas 14 10-yr	3.75	52	2.9	1.4
Atlas 14 100-yr	6.06	85	4.8	2.7
RainyDay 10-yr	4.10	57	3.2	1.6
RainyDay 100-yr	6.68	94	5.4	3.1
2100 5–yr	4.10	57	3.2	1.6
2100 10-yr	4.90	68	3.9	2.1
2100 100-year	7.90	111	6.3	3.8

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Results at 10-acre scale for Milwaukee County

Minor system (10-year)

- Small pipe size and detention volumes using RainyDay vs Atlas 14
- Significant changes in pipe size and detention volume at year 2100 for high emissions scenario

Major system (100-year)

- Significant increases in discharge and runoff volume by 2100

This was an initial look, not a comprehensive study

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Observations

- “Minor” Drainage Infrastructure designed and built now has a service life that will extend well into the “climate change future”
- Using future rainfall projections for the same rainfall return period will result in more minor system cost now – what is prudent?
- Because extraordinarily large floods will become more frequent, conservative design of the “major” surface overflow drainage system is even more important than in the past

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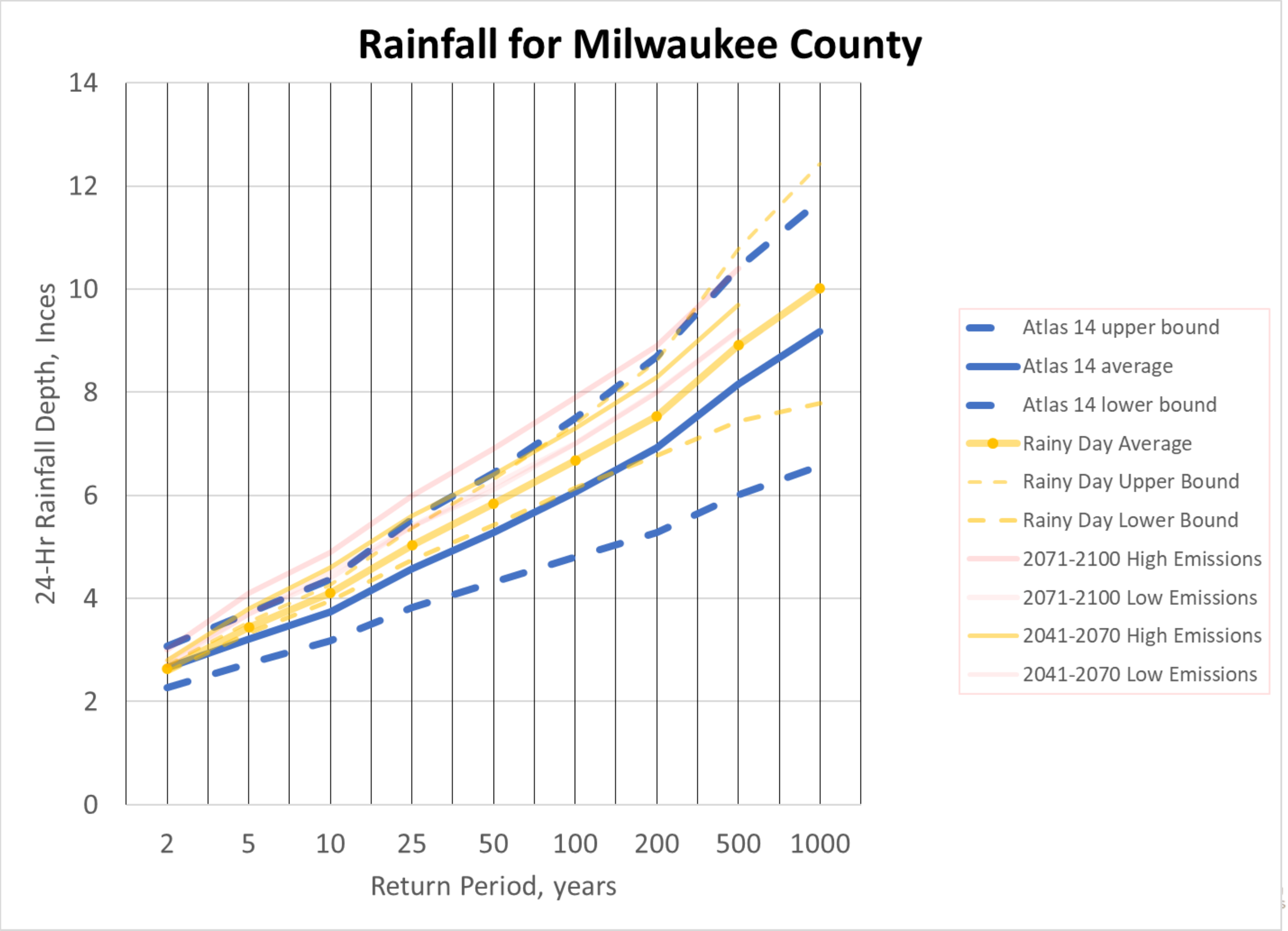
Comparing rainfall statistics for Milwaukee County

- Your County may be different!



A suggestion for today's designers

- Changing code references is a long process
- The difference between Atlas 14 and Rainy Day and Future projections is different in different locations
- Atlas 14 point frequency and NOAA PMP estimates will be revised (probably upward) in the next few years.
- Testing sensitivity (<u>at the design location</u>) using Wisconsin Rainfall Project and Atlas 14 central and 90% upper bound could be an interim approach
- "Future conditions" are more complicated than just rainfall – watershed changes could be as important as climate change
- This issue warrants more detailed analysis!

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