Climate Change and TMDLs: Theory and Practice

2022 NATIONAL TRAINING WORKSHOP ON
WATER QUALITY DATA, ASSESSMENT, AND PLANS
6/2/2022

EPA staff considerations

Outline

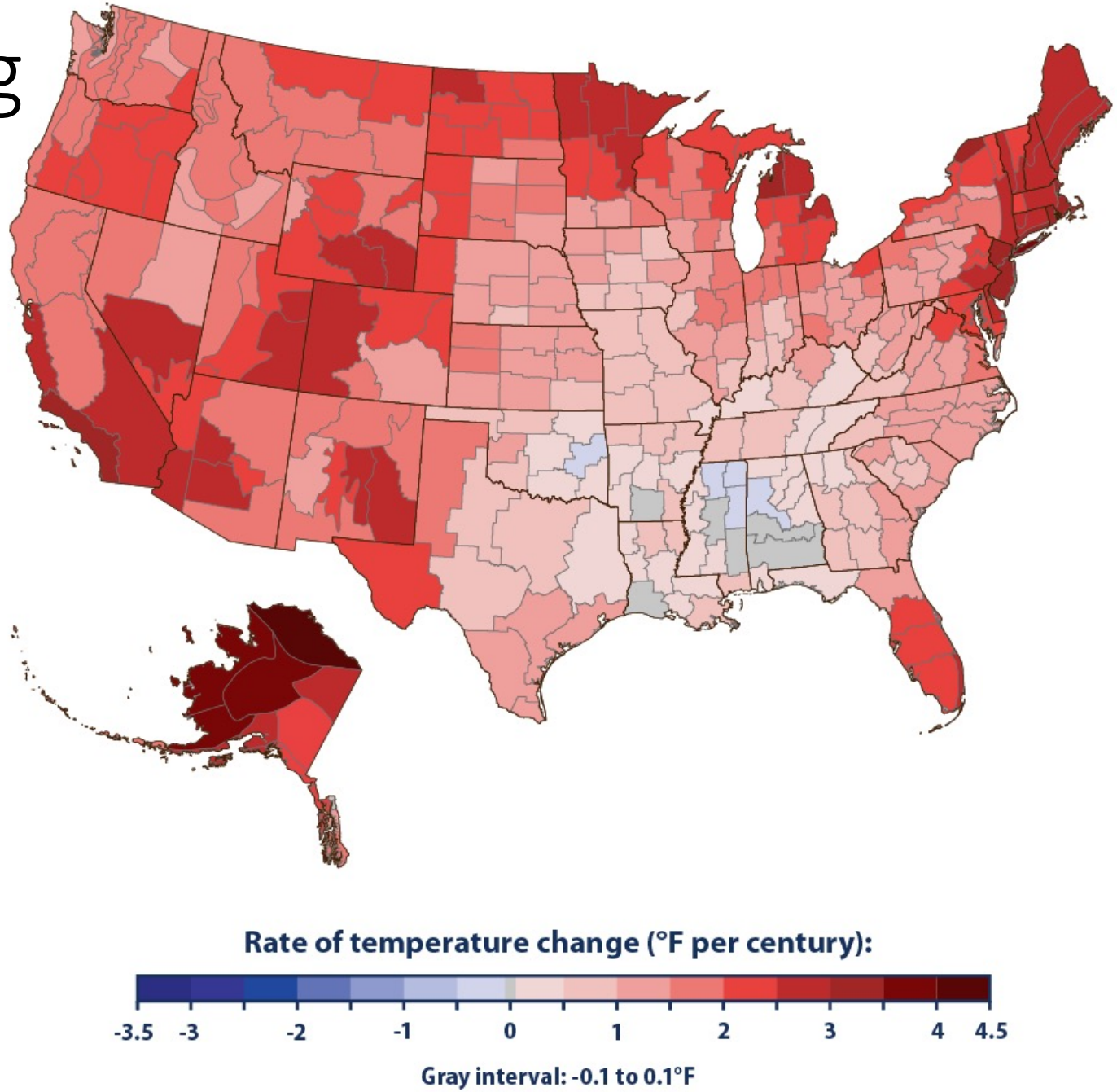
- Focus on Climate Change
- What we heard in recent discussions?
- What we found from review of recent TMDLs?
  - Example MI Statewide *E. coli* TMDL
- Thoughts and discussion on how climate change can be considered in TMDLs:
  - Loading Capacity
  - Margin of Safety
  - Implementation Plan

Where are we heading?

- In ***draft 2022 - 2032 Vision,*** climate change is a cross-cutting theme for growth at the national program level
- An objective of the draft ***Climate Change Focus Area*** would be to strategically consider how to account for the impacts of climate change, or address climate resiliency or vulnerability, in the TMDL process, consistent with water quality standards
- Consider the ***impact of changing environmental conditions on developing and implementing TMDLs***; and their ability to achieve and maintain water quality standards
- EPA will **look to promote opportunities through case studies, tools and guidance** as appropriate

Temperature Increasing

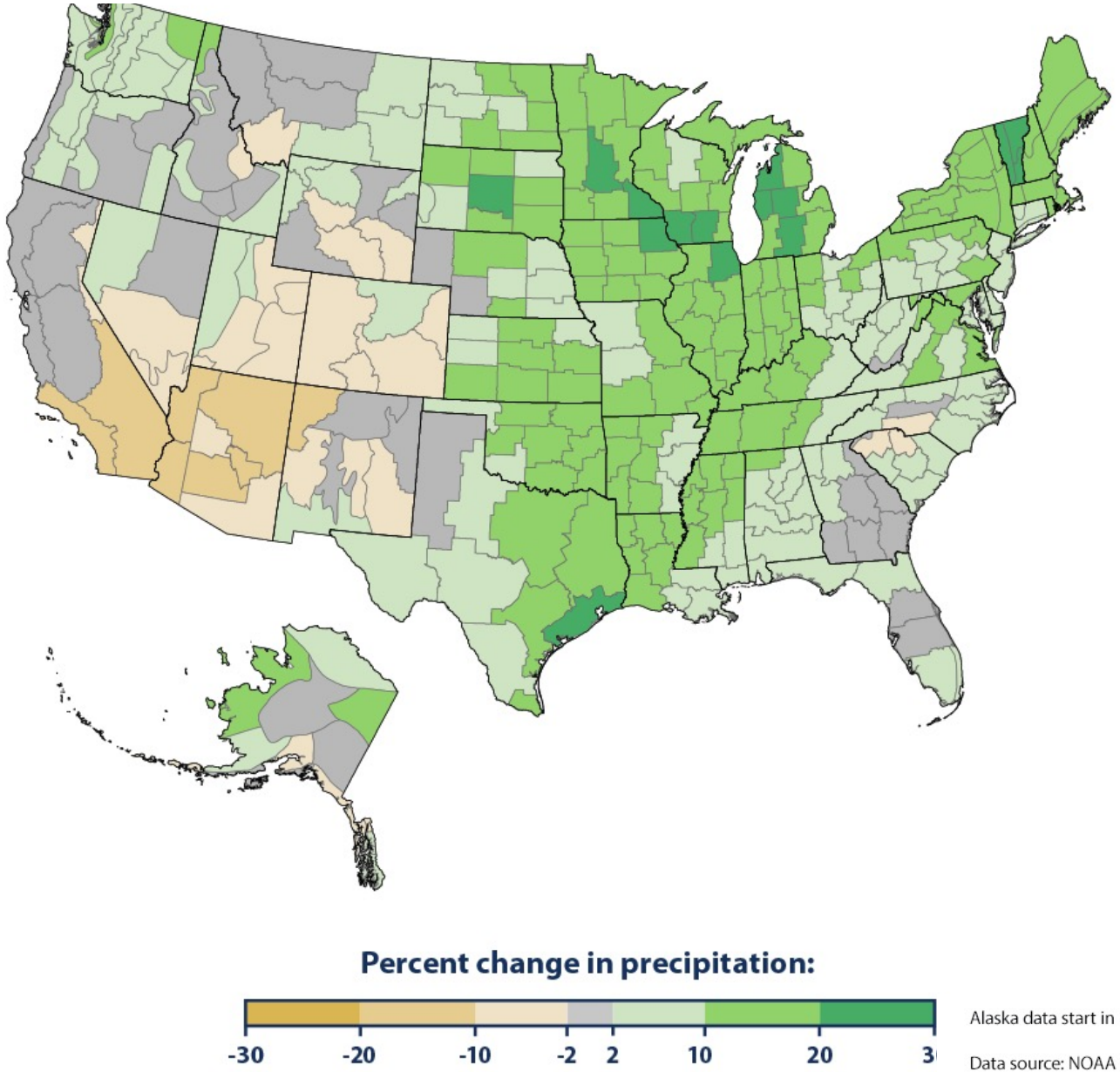
- Temperature has increased over last 100 years
- The North, the West, and Alaska have seen temperatures increase the most
- Some parts of the Southeast have experienced little change
- Average temperatures have risen more quickly since the late 1970s (0.31 to 0.54°F per decade since 1979)



Alaska data start in 1925.

Data source: NOAA (National Oceanic and Atmospheric Administration). 2021. Climate at a glance. Accessed February 2021. www.ncdc.noaa.gov/cag.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.



Precipitation Changing

- Since 1901, global precipitation has increased at an average rate of 0.10 inches per decade, while precipitation in the contiguous 48 states has increased at a rate of 0.20 inches per decade.
- A few areas, such as the Southwest, have seen a decrease in precipitation.
- Not all of these regional trends are statistically significant, however.

Alaska data start in 1925.

Data source: NOAA (National Oceanic and Atmospheric Administration). 2021. Climate at a glance. Accessed February 2021. www.ncdc.noaa.gov/cag.

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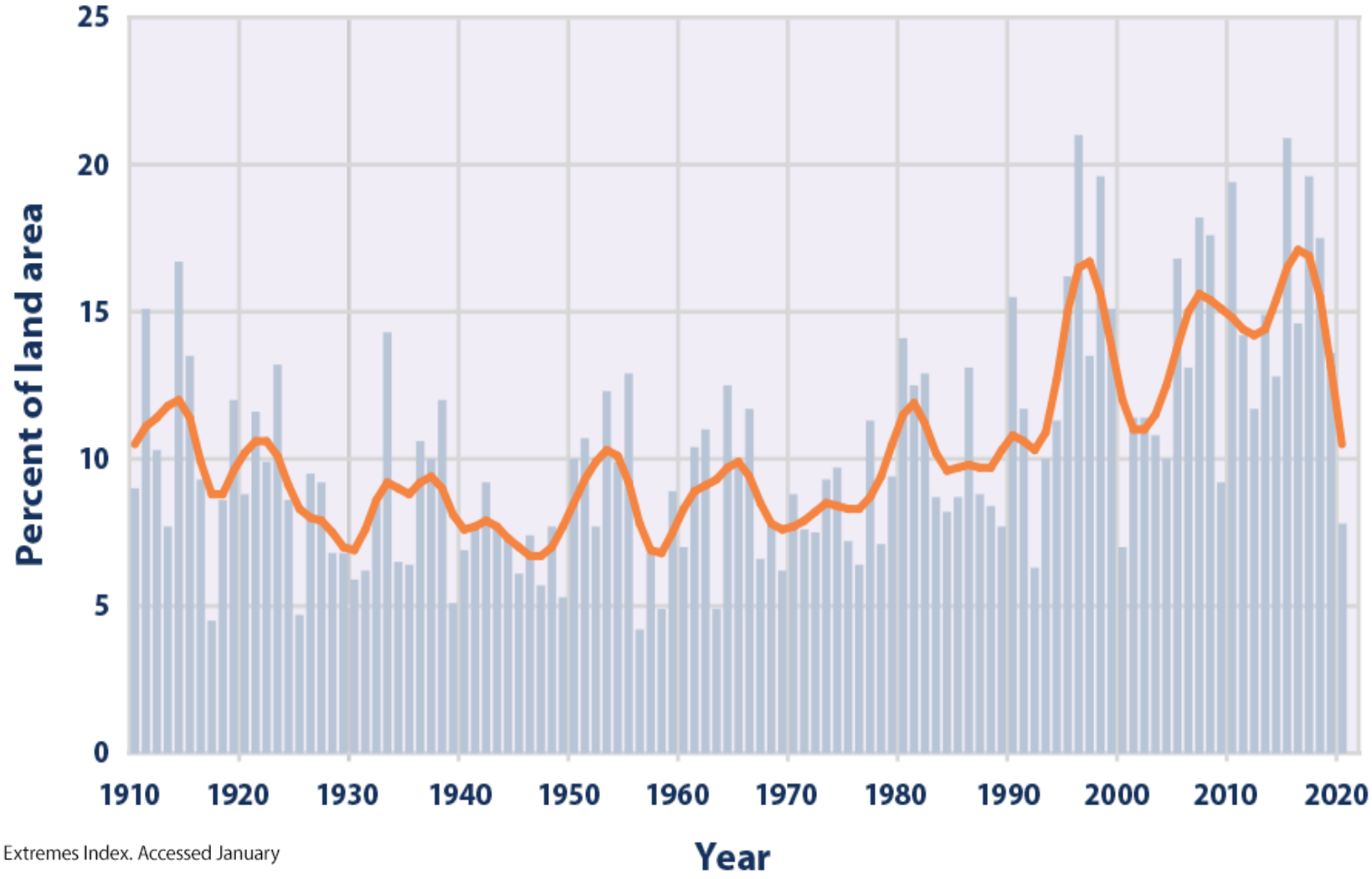
Extreme One-Day Precipitation Events Increasing

- Contiguous US 2010-2020
- In recent years, a larger percentage of precipitation has come in the form of intense single-day events.
- Nine of the top 10 years for extreme one-day precipitation events have occurred since 1996



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Where have we been?

- Recent national discussions have included:
- The 2021 National CWA 303(d) and Data Management Training Workshop contained several session focused on climate change
  - Session 3: Climate Change
  - Session 4: Climate Change and Environmental Justice Discussions and Trainings
- ELI is developing climate change compendium based on information provided from this meeting
- Climate and 303d stakeholders meeting hosted in April

What did we hear?

- Flexible approach
- Frequency/duration curves
- Temperature impairments
- Precipitation variability
- Contaminant reductions

What has EPA been doing?

- EPA reviewing TMDLs where climate change was considered as part of the analysis to understand approaches that have been used
  - At least eleven states and EPA have had substantive discussion of climate change within a TMDL
  - Common impairments – temperature and nutrients
  - Climate change discussion occurred within implementation plans, separate section discussing potential effect on climate change, or margin of safety
  - To our knowledge few TMDLs have incorporated climate change within the TMDL calculation
- EPA developing list of scientific journal articles, law journal articles, technical reports and other white papers that consider climate change in the context of TMDLs
- Using the 2002 TMDL Guidance, EPA staff have considered how each elements could be impacted/address climate change

Our Observations So Far

- Based on our review, the following three sections of a TMDL are where there may be an opportunity (among others) to consider climate change
  - Loading capacity
  - Margin of safety
  - Implementation approaches
- These areas should be viewed as nonexclusive and other approaches may also be appropriate for a specific impairment
- Michigan's Statewide *E. coli* TMDL – Molly Rippke

TMDL areas of focus for climate change

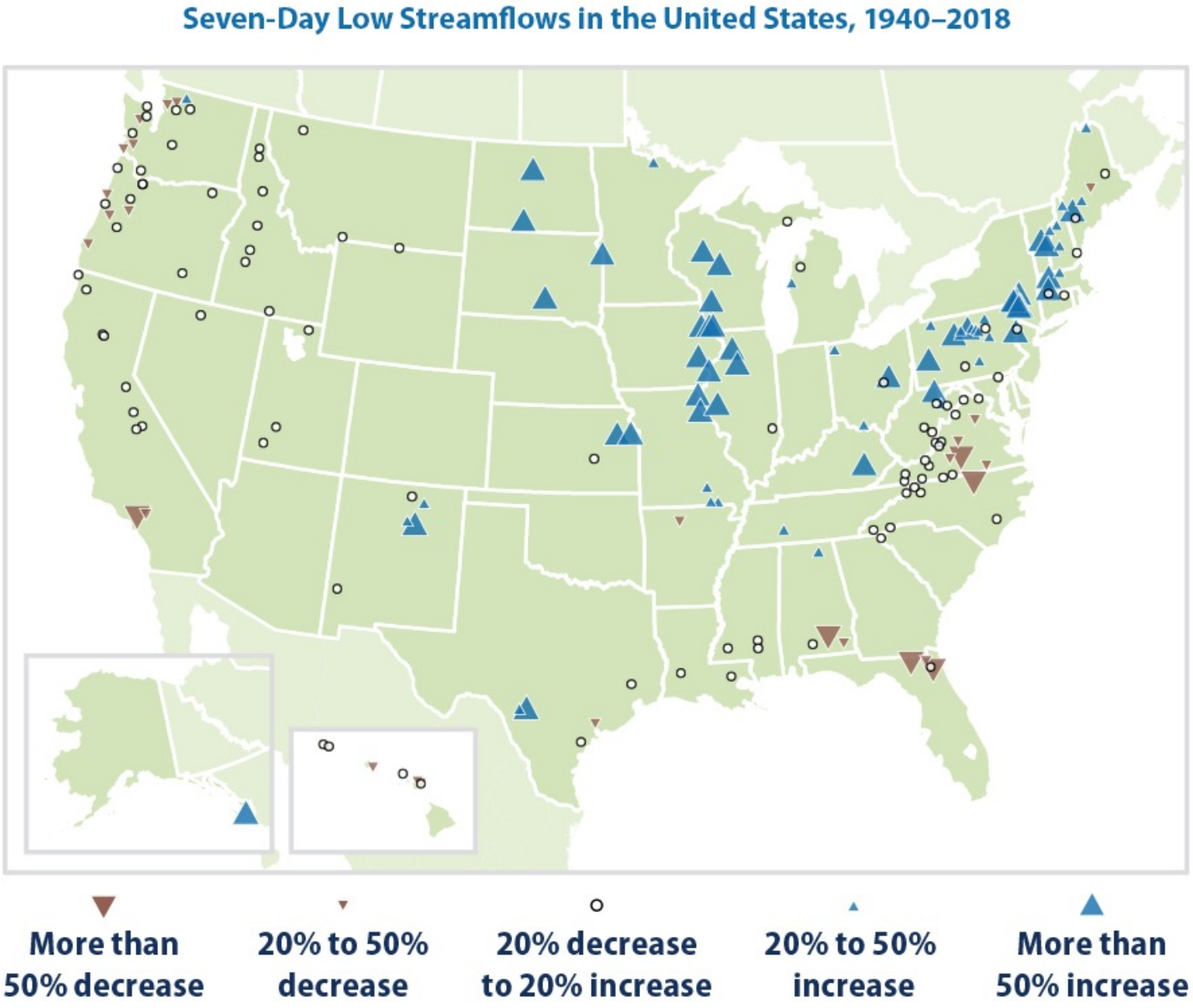
- Loading capacity
  - Critical flow conditions
  - Temperature impairments
- Margin of safety
  - Implicit vs explicit
- Implementation approach

Loading Capacity

- EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards
- A TMDL must identify the loading capacity of a waterbody for the applicable pollutant
- TMDLs take into account critical conditions for steam flow, loading, and water quality parameters as part of the analysis of loading capacity
- With climate change it is possible that the seasonal period of time where critical conditions may be experienced may increase

Critical Conditions: Low Flows

- Change in 7-day low flow over last 80 years
- Increase by more than 50% in Northeast and Midwest
- Some areas of decrease in Southeast and West



Data source: USGS (U.S. Geological Survey). 2020. Analysis of data from the National Water Information System. Accessed June 2020.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

Critical Conditions

- For critical conditions, one could consider if these values have changed or may potentially change as a result of climate change
- For example, for critical low flows one could evaluate the flow record to determine if changes have occurred
- Likewise, if high flow events are part of the critical condition climate change may lead to more of these events
- Where change has occurred, it may be more appropriate to use the most recent part of record, especially if these critical conditions results in less assimilative capacity

Climate change impacts on pollutant loadings

- A clear climate change impact is increase in thermal loadings due to increasing ambient air temperature
- Other pollutants can be more challenging
  - For example, consider nutrients
    - Increased runoff and/or changing growing season can impact source loads
  - Increased in precipitation will lead to more runoff and more export to streams
  - However, increased stream temperatures will lead to increased denitrification and faster removal of instream nitrate

Change in Summer Surface Water Temperatures of North American Lakes, 1985–2009

Total change (°F)

-1 to -0.3 | -0.3 to 0.3 | 0.3 to 1 | 1 to 2 | 2 to 3 | 3 to 4 | > 4

Circles with black borders represent statistically significant trends.

Circles with white borders represent trends that are not statistically significant.

Data source: Sharma, S., et al. 2015. A global database of lake surface temperatures collected by in situ and satellite methods from 1985–2009. Sci. Data 2:150008. doi:10.1038/sdata.2015.8

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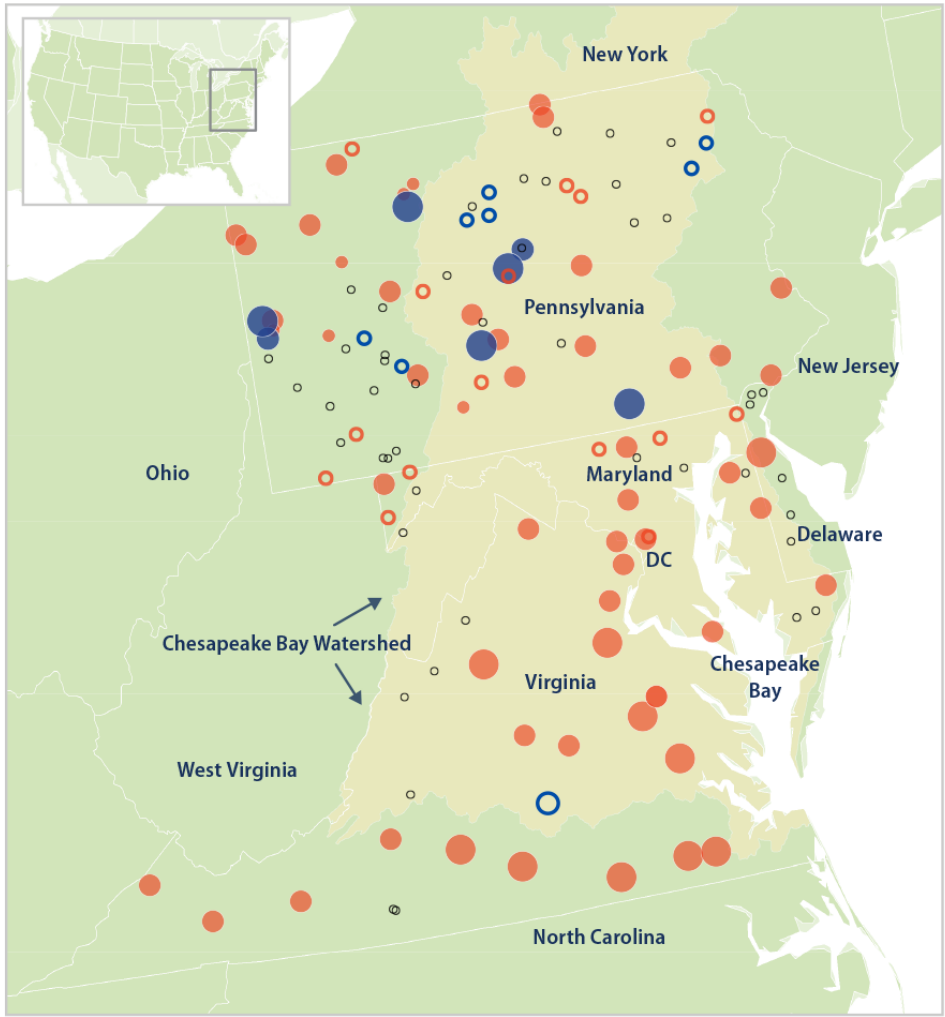
Changes in Stream Water Temperatures in the Chesapeake Bay Region, 1960–2014



Total change (°F):

> -4 | -4 to -2 | -2 to -1 | -1 to 1 | 1 to 2 | 2 to 4 | > 4

Filled shapes represent statistically significant trends.
Open shapes represent trends that are not statistically significant.

Data source: Jastram, J.D., and K.C. Rice. 2015. Air- and stream-water-temperature trends in the Chesapeake Bay region, 1960–2014. U.S. Geological Survey Open-File Report 2015-1207. https://pubs.er.usgs.gov/publication/ofr20151207.

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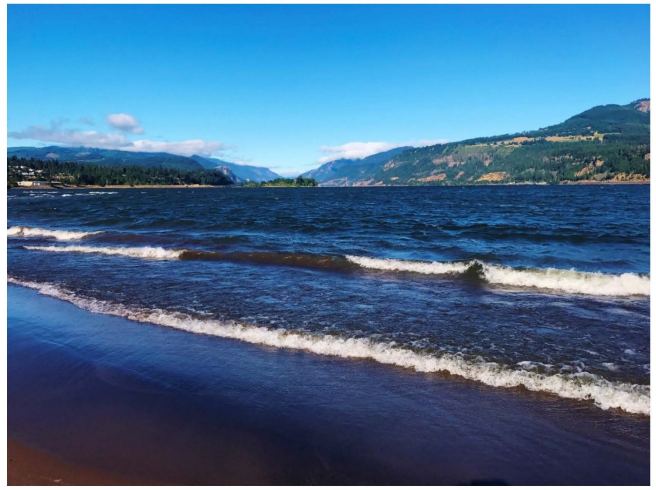
Temperature TMDL Incorporating Climate Change

- Several temperature TMDLs, including the Columbia and Lower Snake, have considered the impacts of climate change
- Climate change has increased summer water temperatures in the Columbia and Snake Rivers by approximately 1.5°C since the 1960s
- The river basin model (RBM-10) results indicate that climate change and dam impacts are the dominant sources impacting river temperatures

Columbia and Lower Snake Rivers Temperature Total Maximum Daily Load

U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue, Suite 155
Seattle, WA 98101-3188



August 13, 2021

Document was revised on May 10, 2022 to correct minor formatting errors and inadvertent omission of a water quality limited segment from Table 1-1 (see letter from Daniel Opalski to Vincent McGowan on October 7, 2021).

Questions for discussion on Load Capacity?

- What approaches does your state use to determine critical conditions and how might these be impacted by climate change?
- How can one assess the impact of climate change, relative to other sources or variables within the TMDL?
- How can models be used to evaluate the impacts of climate change?

Margin of Safety (MOS)

- TMDL must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality
- Implicit
  - Incorporated into the TMDL through conservative assumptions in the analysis
  - The conservative assumptions in the analysis that account for the MOS must be described
- Explicit
  - Expressed in the TMDL as loadings set aside for the MOS
  - The loading set aside for the MOS must be identified

Margin of Safety (MOS): Implicit

- Cape Cod embayments TMDLs used an implicit MOS that considered climate change
- “Because the science is not yet available, MassDEP is unable to analyze climate change impacts on streamflow, precipitation, and nutrient loading with any degree of certainty for TMDL development. In light of these uncertainties and informational gaps, MassDEP has opted to address all sources of uncertainty through an implicit MOS. MassDEP”

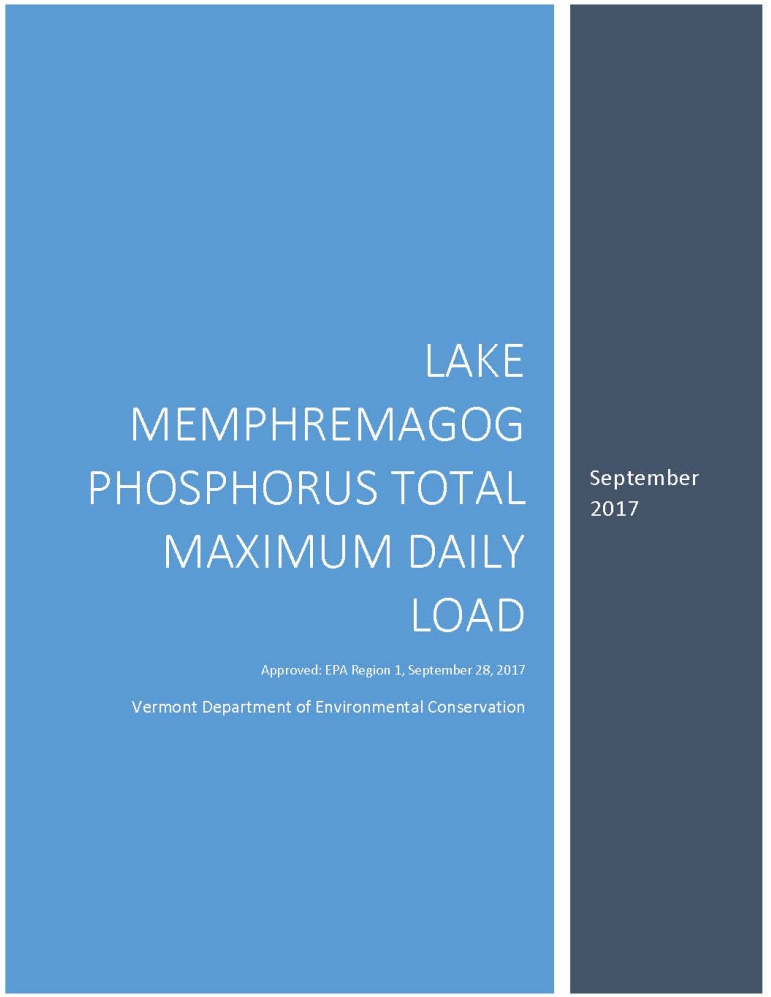
Final Fiddlers Cove and Rands Harbor Embayment Systems
Total Maximum Daily Loads for Total Nitrogen
(Control # 394.1)

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MATTHEW A. BEATON, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
DOUGLAS FINE, ASSISTANT COMMISSIONER

November 2017

Margin of Safety (MOS): Explicit

- Lake Champlain and Lake Memphremagog TMDLs considered climate change in the explicit MOS
  - Lake Champlain "EPA determined that it was not necessary to increase the MOS above the 5% already identified to account for possible, far-term effects of climate change"
  - Lake Memphremagog did include "uncertainties related to potential increases in flows and loading with climate change" among other items justifying an 8% MOS



Questions for discussion on MOS?

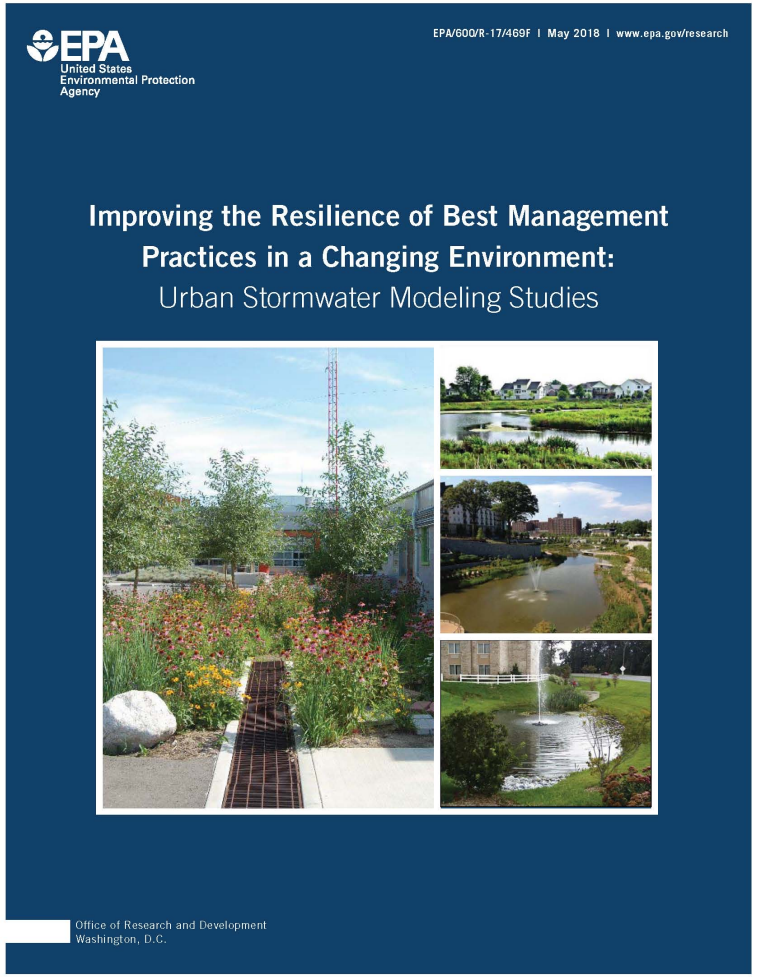
- What analysis would be needed in order to incorporate climate change in the explicit MOS?
- What approaches can be used to develop conservative assumptions for climate change for an implicit MOS?
- How can computational models be used for developing a TMDL MOS?

Implementation Approaches

- EPA is not required to and does not approve TMDL implementation plans
- EPA policy encourages working in partnership with States/Tribes to achieve nonpoint source load allocations
- Reasonable assurances needed for mix source waters
- States/Tribes can develop implementation plans to address reasonable assurances that loads will in fact be achieved
- EPA encourages the use of adaptively managed TMDL implementation plans/approaches that are designed to adjust BMPs and other interventions in response to new information collected post-TMDL approval

Climate Ready BMPs

- Need climate ready approaches for addressing both WLA (storm water) and LA implementation
- Recent studies have shown that changes in land and resource use will have a comparable or greater effect on water quality than changes in temperature and precipitation (Murdoch et al., 2000)
- Practices less sensitive to changes in climatic conditions will be more likely to function as intended as climate changes. More flexible/adaptable practices that can be revised or phased in over time provide a hedge against future risk. (Johnson et al., 2022)



South Fork Nooksack River Temperature TMDL

- TMDL implementation plan used modeling to evaluate climate change scenarios
- Without restoration of riparian shade, maximum water temperatures during critical summer low-flow conditions could increase by almost 6°C by the 2080s
- Restoration of full system potential riparian shading at 100 years can help buffer against temperature increases
- When combined providing cold water refuges during high-temperature events, can provide substantial resiliency into the future that will help protect designated uses

South Fork Nooksack River Temperature Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

DEPARTMENT OF ECOLOGY
State of Washington

February 2020
Publication No. 20-10-007

Questions on Implementation Approaches?

- Are there best practices for how to approach climate change in TMDL implementation approaches?
- How can implementation activities be prioritized based on climate change impacts?
- How can computational models be used to simulated the effectiveness of different BMPs under potential future climate conditions?
- How can TMDL implementation approaches mitigate against potential future loading increases as a result of climate change?

Other Questions?

- Are there other important intersections between climate and TMDLs missing from what was covered?
- What additional information would your state need to consider including climate change within a TMDL?
- What tools should EPA consider developing to encourage and support TMDLs that evaluate the impacts of climate change?