Integrating Planning for Transportation and Stormwater Infrastructure

Presented at *23rd Annual SAME Infrastructure Forum* *February 9th, 2024*

Nick Z. Fang Ph.D., P.E.

Professor, Robert S. Gooch Endowed Fellow

Water Resources Eng. | Urban Water Inst. |Civil Engineering Dept. | UTA

FANG RESEARCH GROUP
—WATER RESOURCES
The University of Texas at Arlington

U.S. Billon-Dollar Disasters in 2022

Flood in Dallas , Texas on August 2022 –
(Source: Dallas Morning News)

Winter Storm/Cold Wave

North Central and Eastern Severe Weather July 22–24

Central and Eastern Winter Storm and Cold Wave December 21–26

Central Derecho June 13

Kentucky and Missouri Flooding July 26–28

Southeastern Tornado Outbreak April 4–6

Hurricane Nicole November 10–11

Hurricane Ian September 28–30

Hurricane Fiona September 17–18

Texas Hail Storms February 21–22

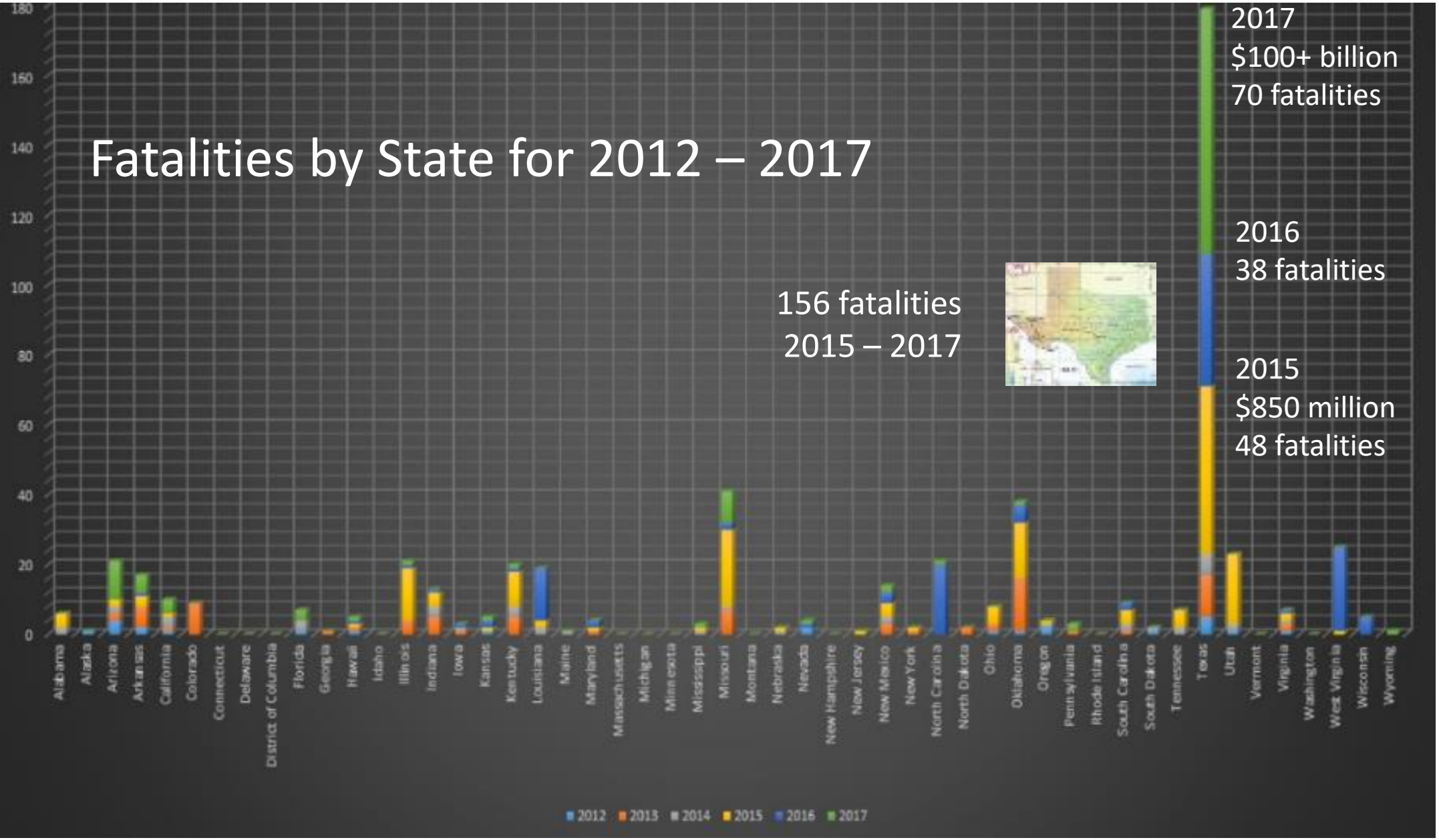
Severe Weather April 11–13

Tornado Outbreak March 30

*This map denotes the approximate location for each of the **18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.***

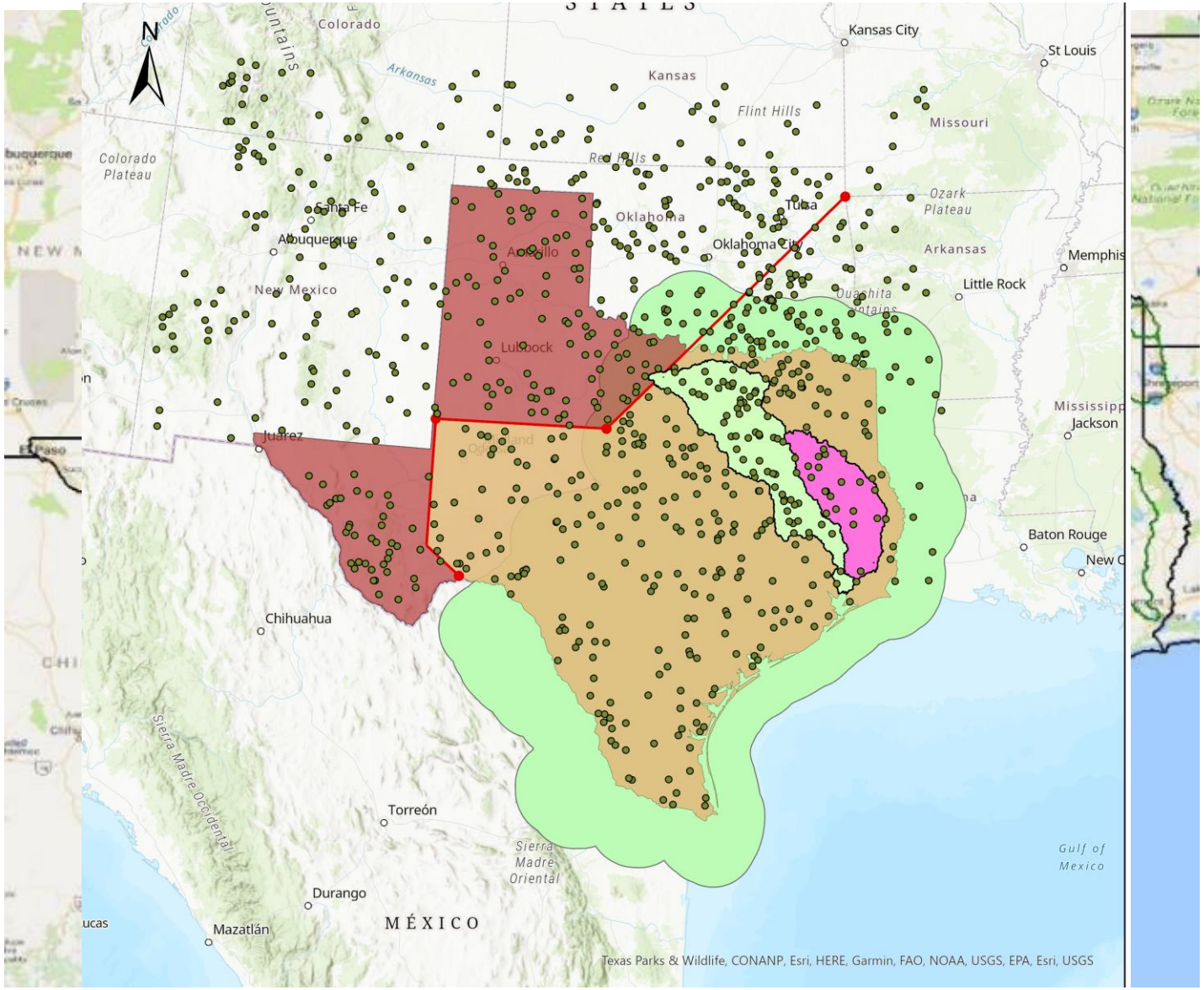
Why TSI?

Fatalities by State for 2012 – 2017



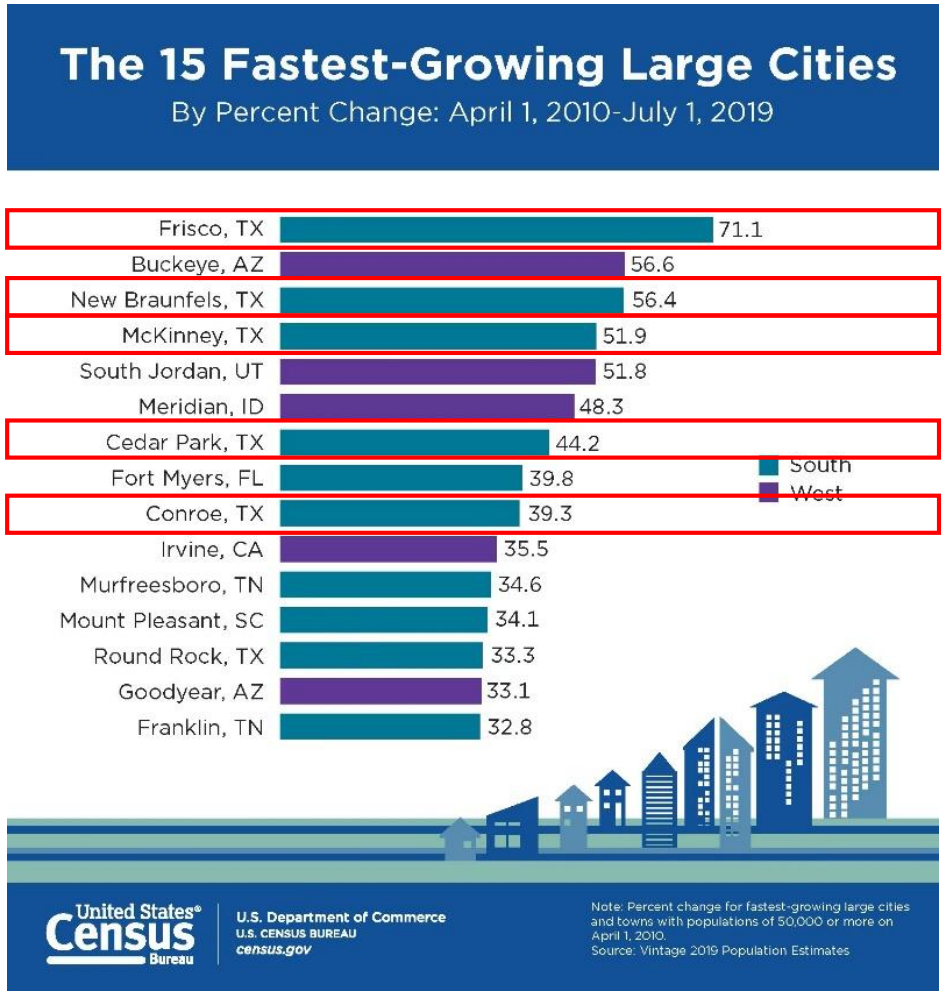
Source: Gregory Waller, Service Coordination Hydrologist, NWS – West Gulf River Forecast Center, http://www.nws.noaa.gov/om/hazstats.shtml

Extreme Storms (2010 – 2019)



integrating Transportation & Stormwater Infrastructure

Population Growth in U.S. highlighting TX



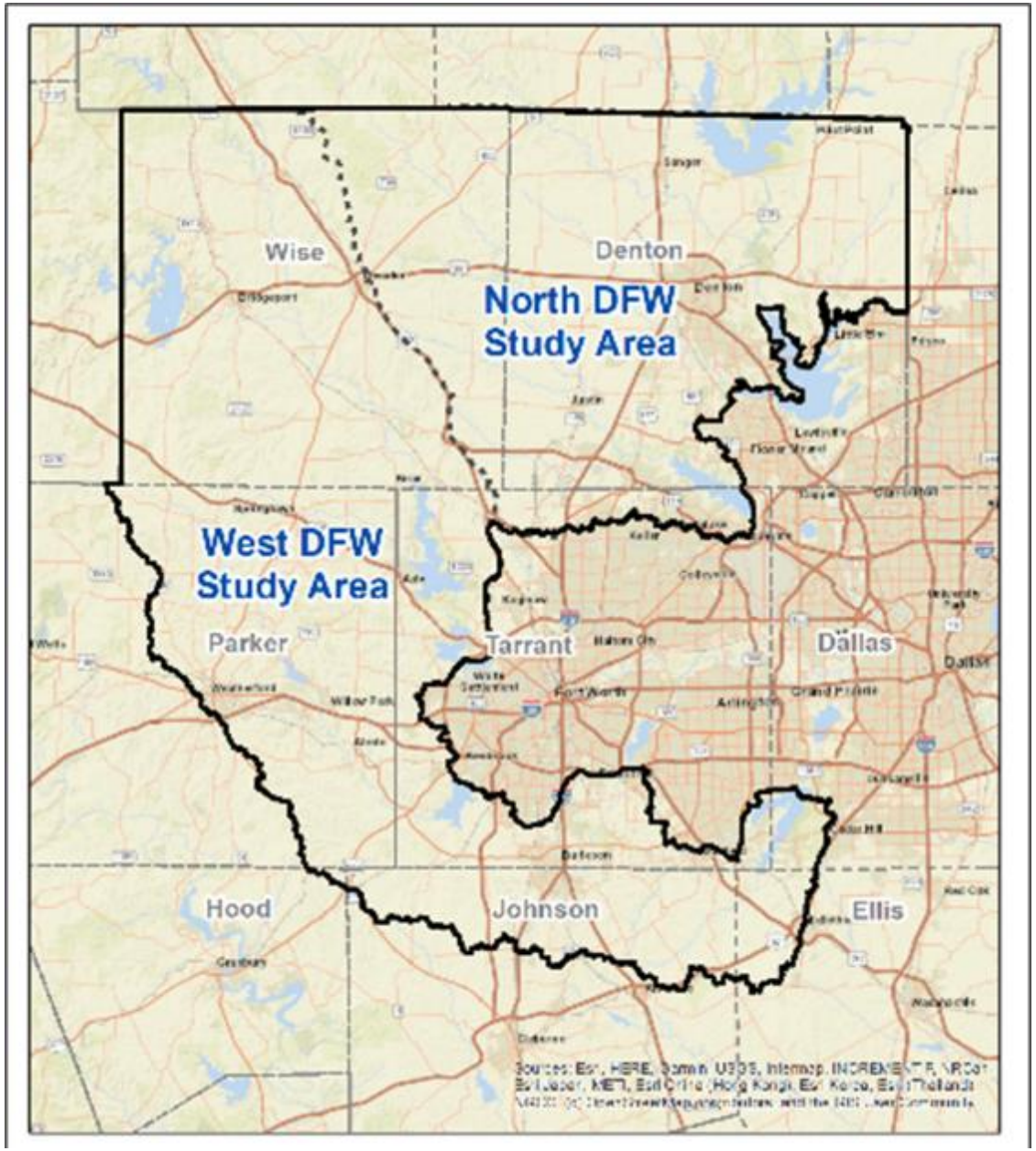
Project Details

Purpose

- Prevention vs. response
- Integrate stormwater management, urban development, transportation, and environmental planning
- Develop plan for risk awareness and resiliency
- Identify impacts and alleviate risks from flooding

Timeline & Budget:

- Official kickoff March 2023
- Completion date for first phase: June 2025
- Funding for first phase: $6 million

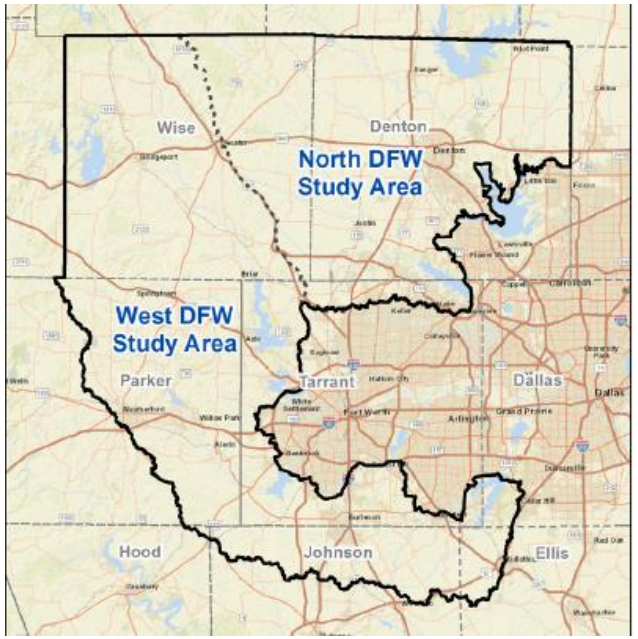


integrating Transportation & Stormwater Infrastructure

Project Team Members

North Central Texas Council of Governments

US Army Corps of Engineers



UNIVERSITY OF TEXAS ARLINGTON

trwd Tarrant Regional Water District

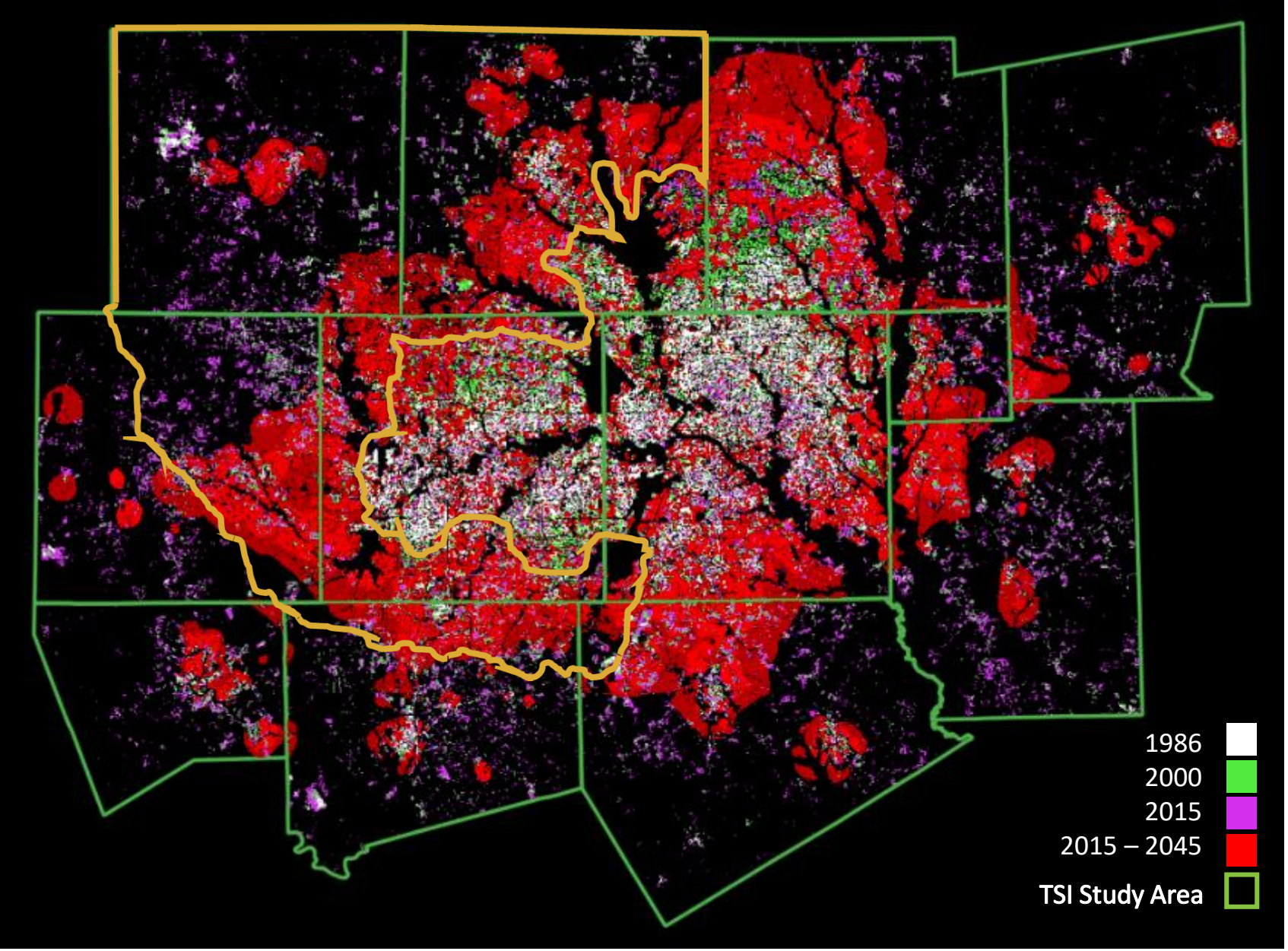
TEXAS A&M AGRILIFE

Funding Partners

Texas Water Development Board

Texas Department of Transportation/Federal Highway Administration

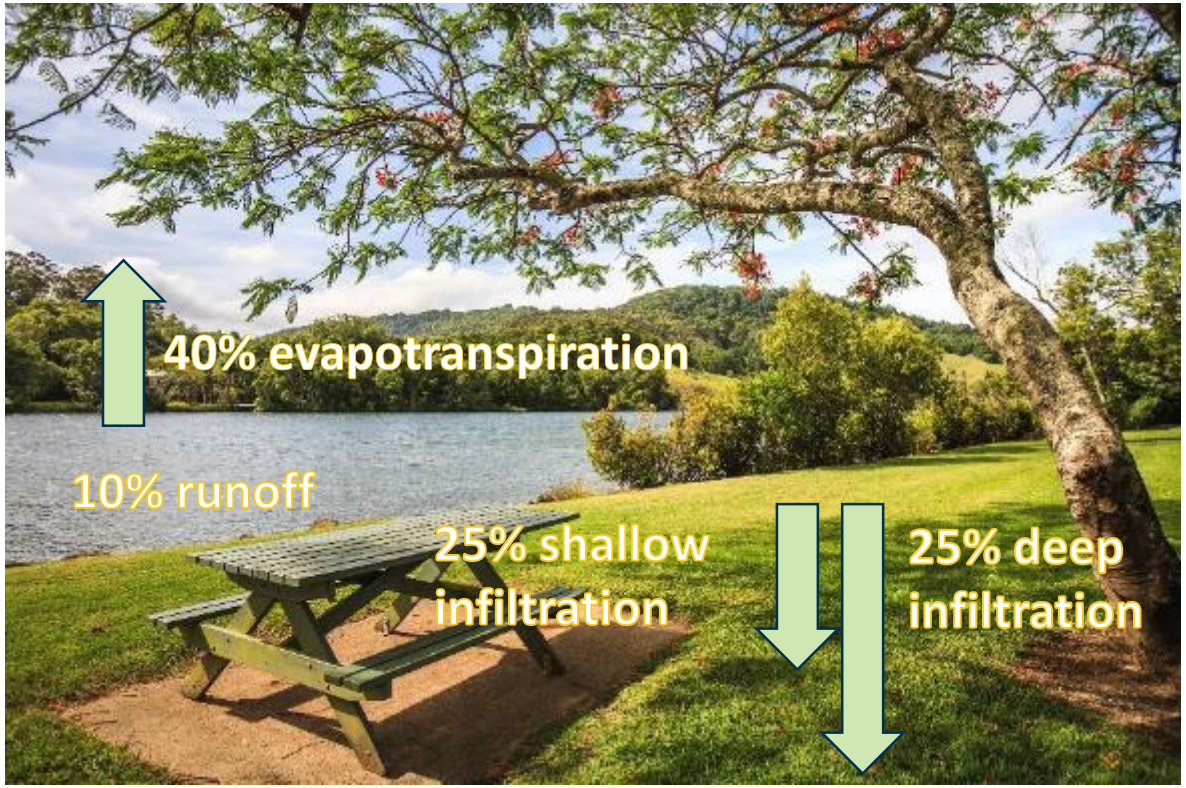
Federal Emergency Management Agency



Why TSI?

- 60% undeveloped (2015)
- 19% growth in impervious surface (2006 – 2016)
- 126% increase in population (2020 – 2045)
- >7,000 miles of streams >274,000 acres of 100-year floodplain
- DFW Metroplex as the 4th largest area in the U.S.

Urbanization Challenges

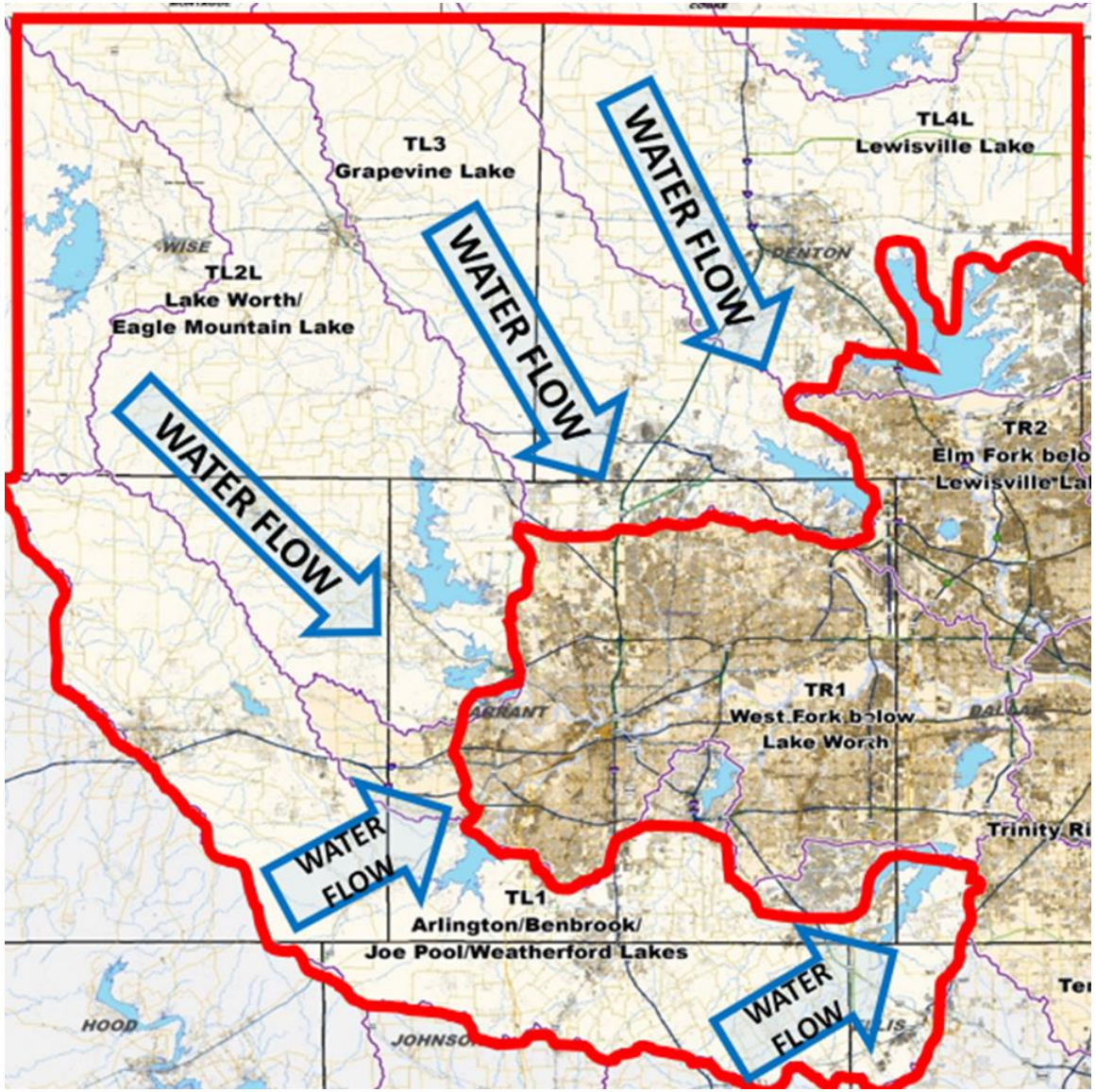


BEFORE (Natural Ground Cover)

After (75%-100% Impervious Cover)

Stormwater Challenges

- No regionwide data
- Piece-meal/lacks connectivity
- NOAA Atlas 14 rainfall estimates
  - Required for infrastructure design, planning, and delineation of flood risk
  - 2022 FLOODS Act
  - 10-year updates



Transportation Challenges

- Transportation spending is high and growing
- Rate of deterioration for transportation infrastructure increasing
- Needs can outweigh resources for local governments

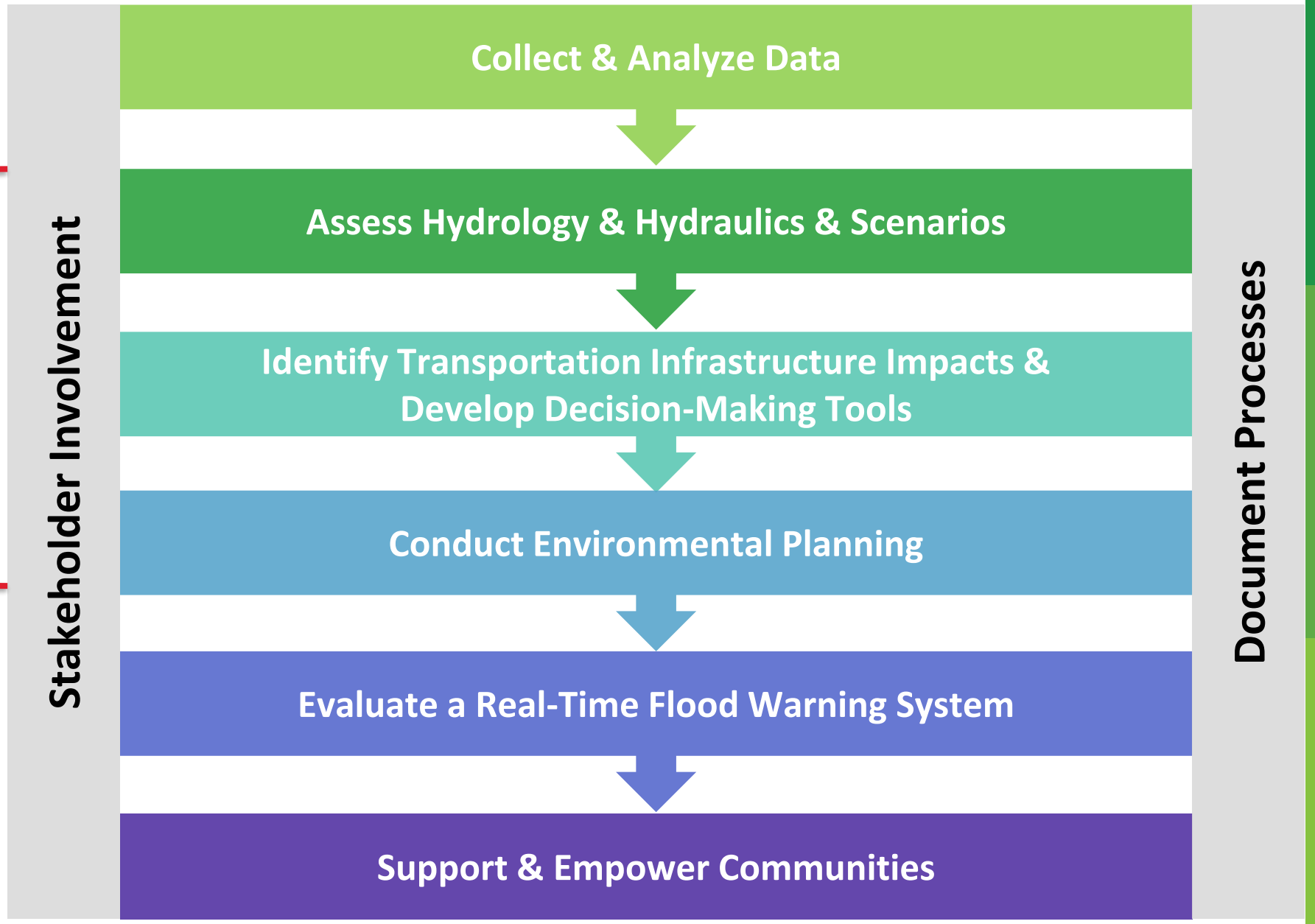
Exhibit 2-4: Major Expenditures

Mobility 2045 Update Planning Approach	
Infrastructure Maintenance*	$42.8
Management and Operations	$9.6
Growth, Development, and Land Use Strategies	$1.5
Rail and Bus**	$44.9
HOV/Managed Lanes + Freeways/Tollways and Arterials	$49.5
Total, Actual $, Billions	**$148.3**

Values may not sum due to independent rounding
*Includes transit system maintenance
**Transit capital expenditures, including those using innovative revenue sources such as public-private partnerships

Source: NCTCOG, Mobility 2045 Update

Mapping, Modeling, and Policy Recommendations



integrating Transportation & Stormwater Infrastructure

How Can *WE* Accomplish This?

- TSI benefits from valuable flood hazard awareness and resiliency information that has helped reduce uncertainty related to flood risk
- Enables us to further enhance and integrate this information at a regional scale
- Without this information, it would require extensive effort on the front end of the project to get here

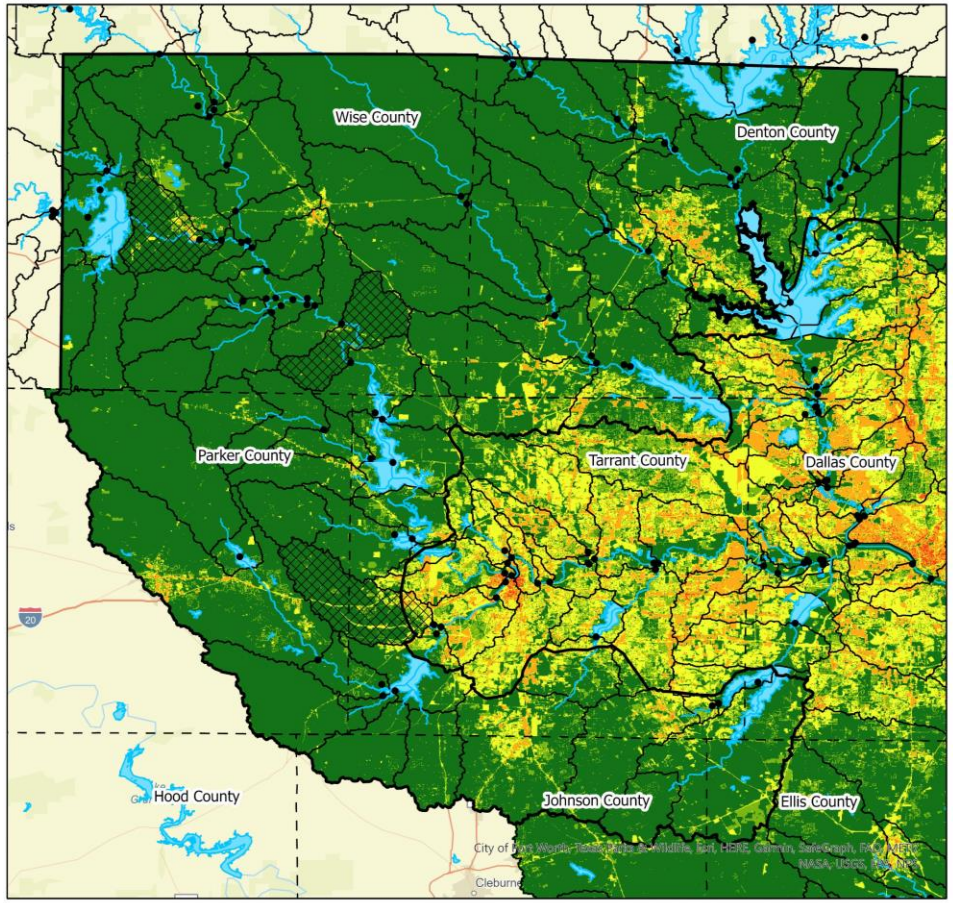
Leverage existing Flood Risk Management initiatives…

… to innovate at a regional scale

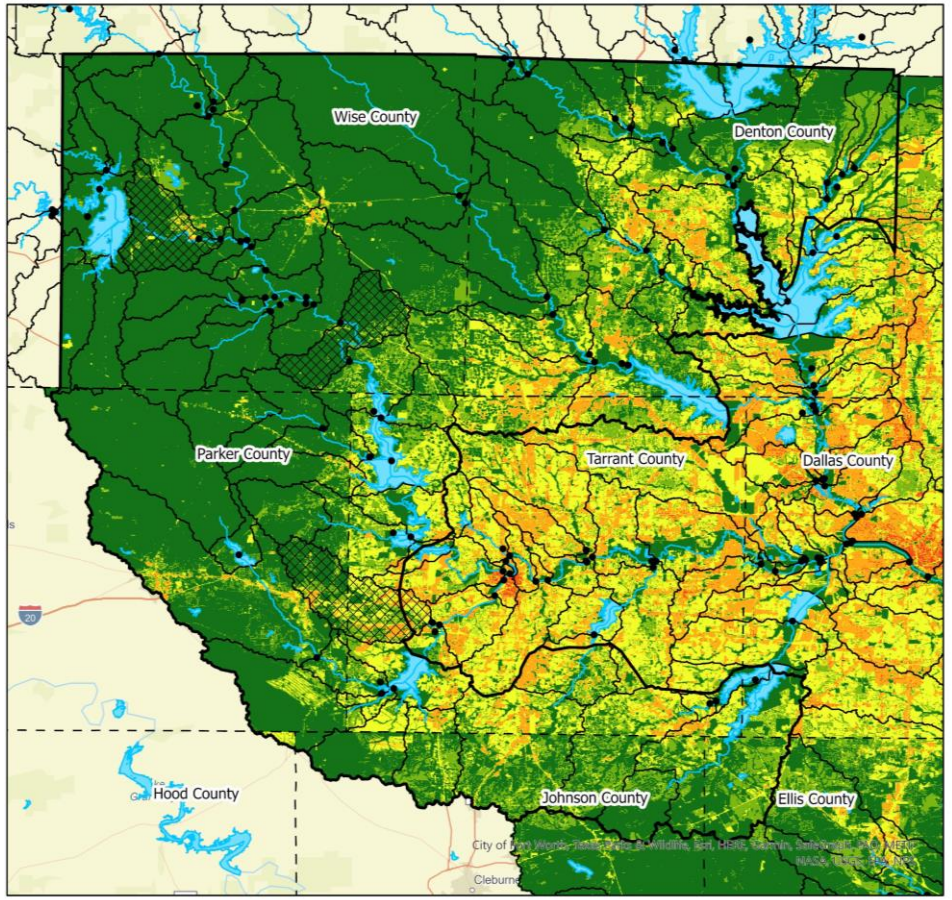
*Data from: NCTCOG Transportation Group Demographic Team

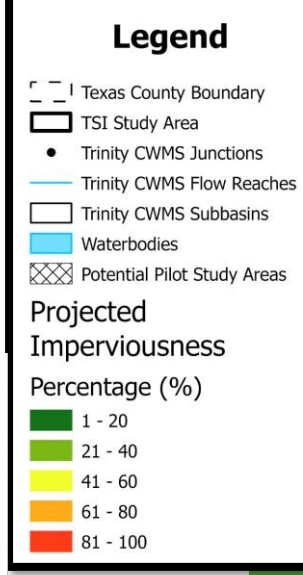
Projected Imperviousness by Year

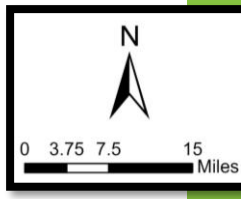
2020



2070



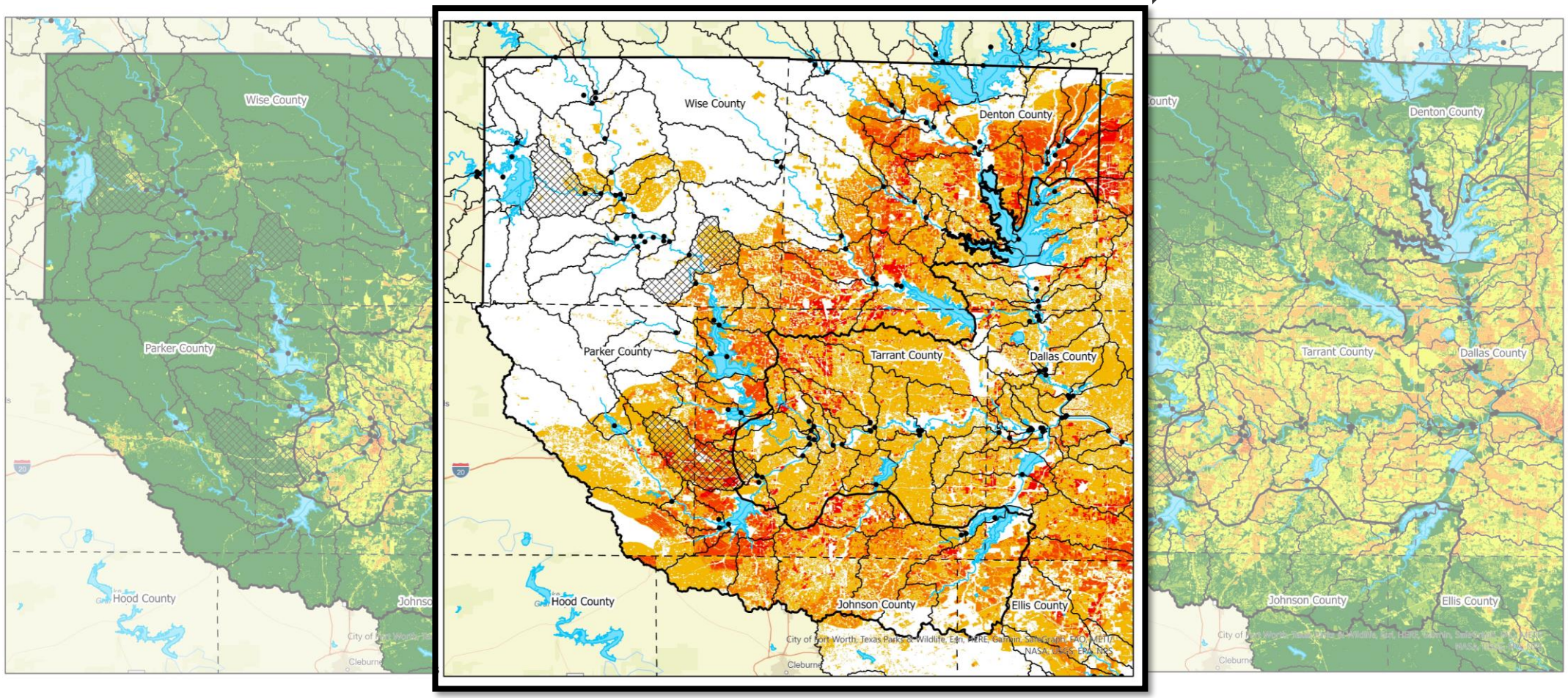




*Data from: NCTCOG Transportation Group Demographic Team

Projected Imperviousness Change

2020 → 2070



Legend

- Texas County Boundary
- TSI Study Area
- Trinity CWMS Junctions
- Trinity CWMS Flow Reaches
- Trinity CWMS Subbasins
- Waterbodies
- Potential Pilot Study Areas

Imperviousness Change

Percentage (%)

- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80

N

0 3.75 7.5 15 Miles

integrating Transportation & Stormwater Infrastructure

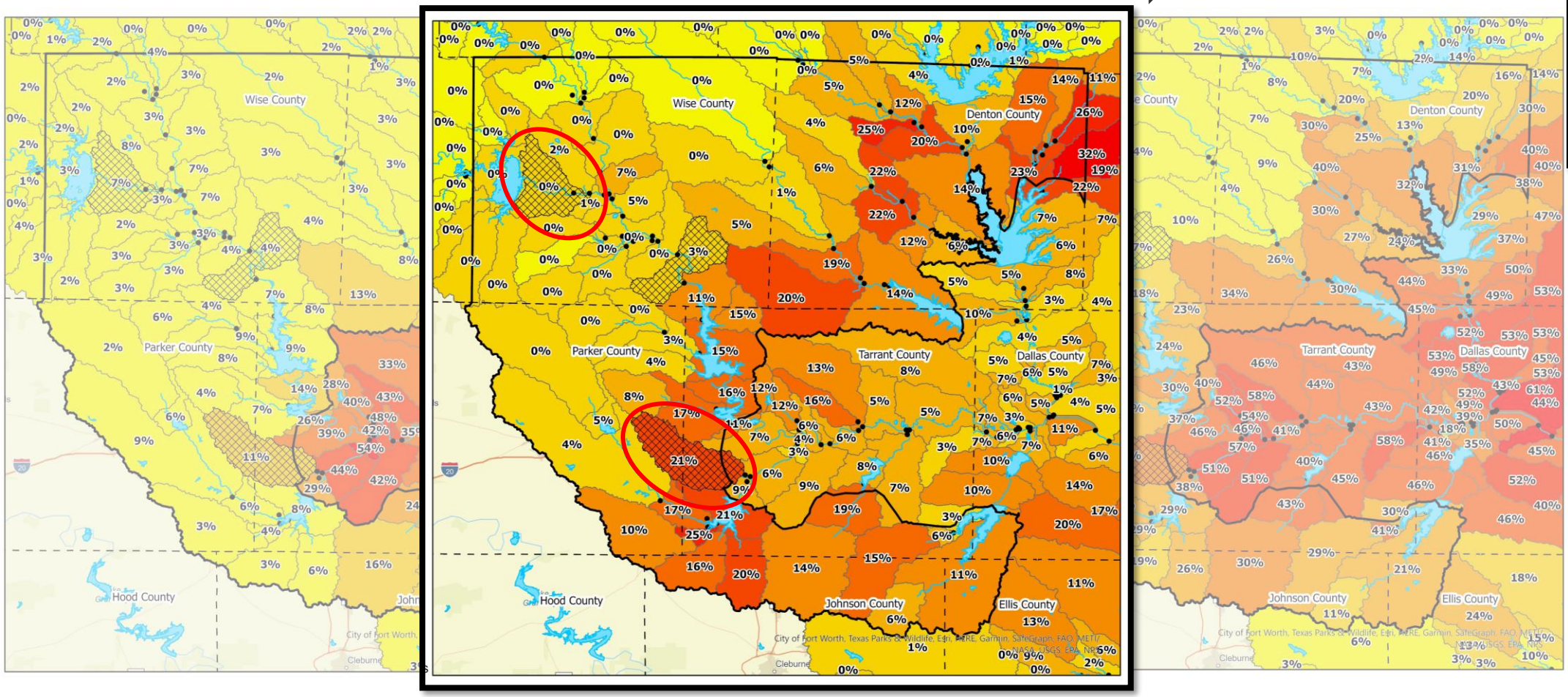
North Central Texas Council of Governments

FANG RESEARCH GROUP — WATER RESOURCES — The University of Texas at Arlington

*Data from: NCTCOG Transportation Group Demographic Team

Average Projected Imperviousness Change by Subbasin

2020 → 2070



Legend

- Texas County Boundary
- TSI Study Area
- Trinity CWMS Junctions
- Trinity CWMS Flow Reaches
- Waterbodies
- Potential Pilot Study Areas

Average Projected Imperviousness

- 0% - 10%
- 11% - 20%
- 21% - 30%
- 31% - 40%
- 41% - 50%
- 51% - 60%
- 61% - 70%

N

0 3.75 7.5 15 Miles

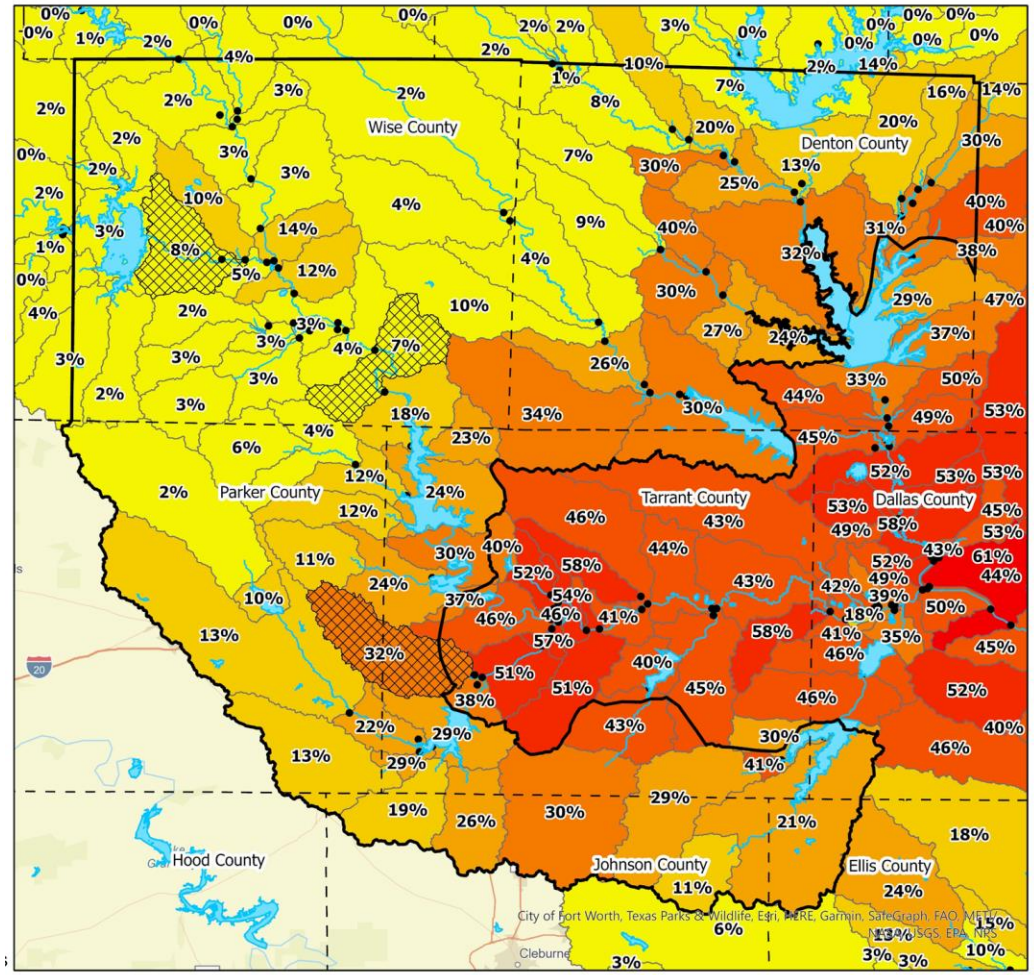
integrating Transportation & Stormwater Infrastructure

North Central Texas Council of Governments

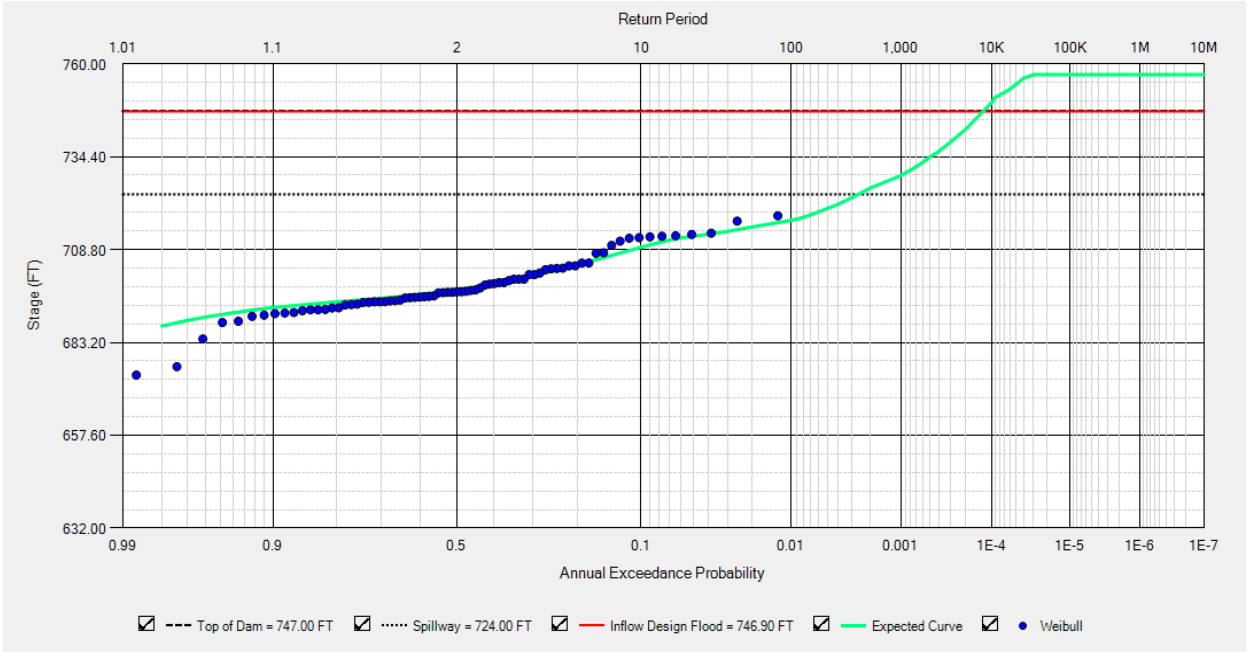
FANG RESEARCH GROUP — WATER RESOURCES — The University of Texas at Arlington

Reservoir-Inflow Frequency Study

2070



Benbrook Stage Frequency *Preliminary*

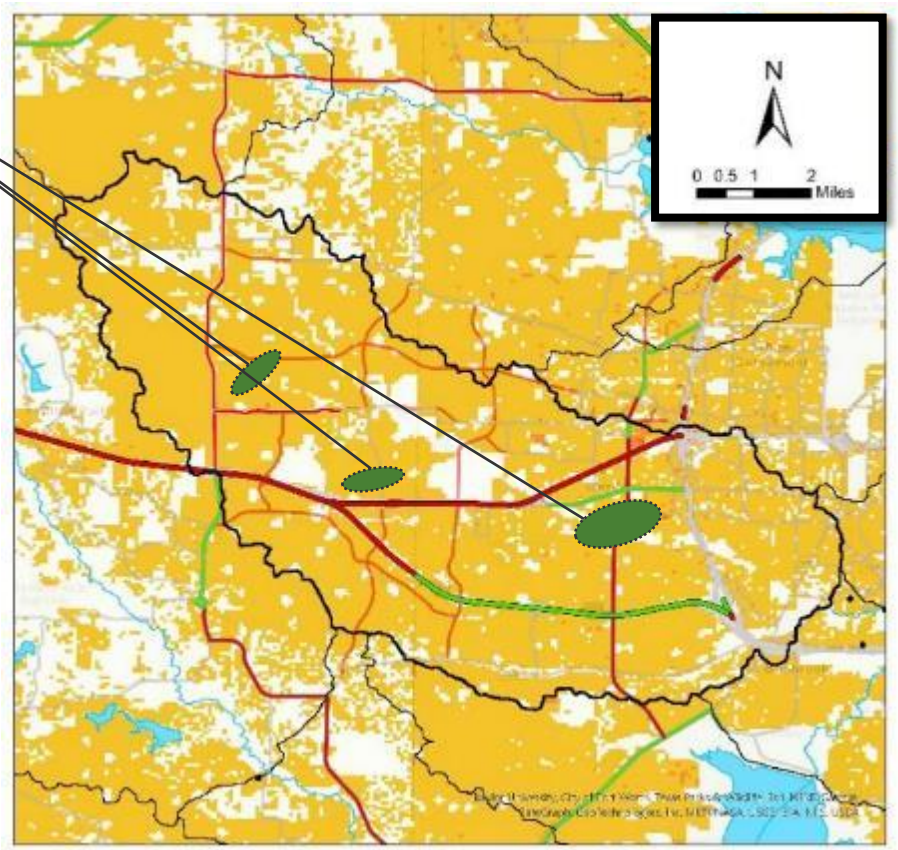


integrating Transportation & Stormwater Infrastructure

US Army Corps of Engineers.

FANG RESEARCH GROUP
WATER RESOURCES
The University of Texas at Arlington

Pilot Study Area Investigation
Mary's Creek (2D-Area) – 2045 Land Use Projection



Legend

- Trinity CWMS Junctions
- Trinity CWMS Flow Reaches
- Waterbodies
- Potential Pilot Study Areas
- Trinity CWMS Subbasins

Legend

- Trinity CWMS Junctions
- Trinity CWMS Flow Reaches
- Waterbodies
- Potential Pilot Study Areas

Network
- 2023
- 2045

Mobility 2045
- Non-Regionally Significant Arterial

Regionally Significant Arterial

Recommendation
- No
- Yes
- Other

Major Roadway (Freeway/Tollway)

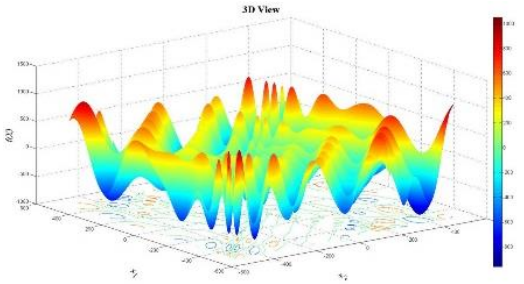
Recommendation
- No
- Yes
- Other
- Trinity CWMS Subbasins

Imperviousness Change (2020 to 2045)

Percentage (%)
- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80

integrating **Transportation & Stormwater Infrastructure**

Optimization Methodology



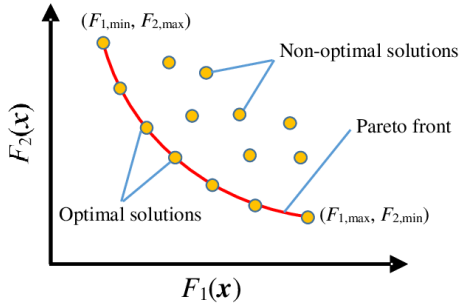
Receive updated HEC-HMS model and modify for optimization

Conduct GIS-based suitability analysis for the menu of traditional and green infrastructure options

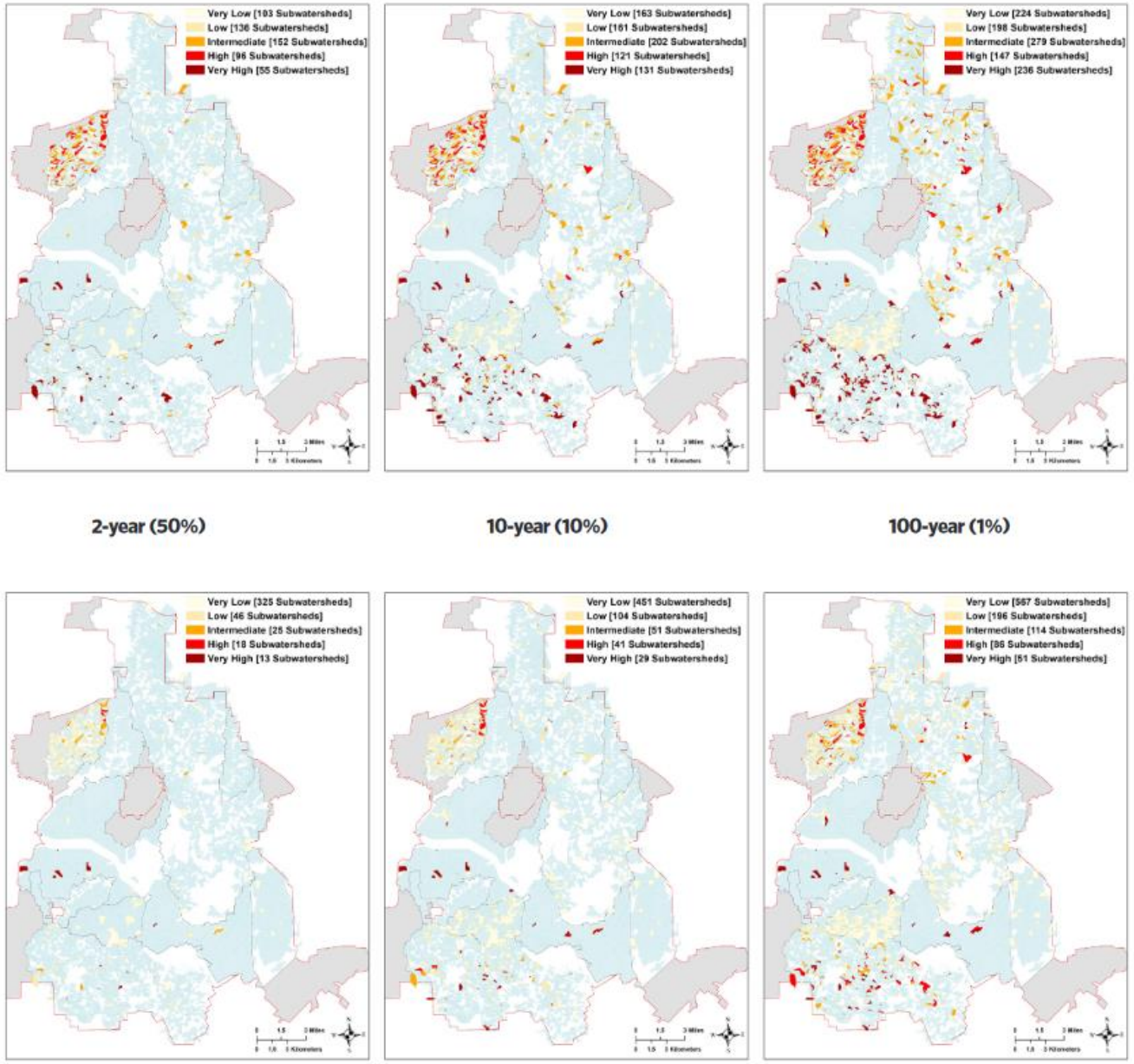
Set up variables and initial data for traditional and green stormwater infrastructure options

Determine objective function and constraints with emphasis for on-stream and environmentally-conscious solutions

Develop and run a script using optimization techniques and algorithms to work with the HEC-HMS model



Modeling Green Stormwater Infrastructure



- GSI reduces modeled overflows for all storms in Dallas study
- GSI 77%less costly than gray infrastructure alone
- Bioretention provides biggest bang for buck

The Nature Conservancy

https://www.nature.org/content/dam/tnc/nature/en/documents/GSIanalysisREVFINAL.pdf

Bardia Heidari, Victoria Prideaux, Katherine Jack, Fouad H. Jaber. 2023. A planning framework to mitigate localized urban stormwater inlet flooding using distributed Green Stormwater Infrastructure at an urban scale: Case study of Dallas, Texas, Journal of Hydrology, Volume 621, https://doi.org/10.1016/j.jhydrol.2023.129538.

Questions and Discussion

integrating **Transportation & Stormwater Infrastructure**

Contact

Nick Fang, Ph.D., P.E.
Professor, Water Resources
Civil Engineering Department
The University of Texas at Arlington
817-272-5334
nickfang@uta.edu