Sustainable Levee Systems through Applied Collaborative Research

MRNRC, March 12-14th, 2024

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Charles van Rees, and Brian Bledsoe

About Me

- Research Engineer with IRIS
- PhD student with UGA
- Mechanical engineering training
- Research focus
  - NbS for coastal and riverine infrastructure systems
  - Translating research to practice

Institute for Resilient Infrastructure Systems
UNIVERSITY OF GEORGIA

NETWORK FOR ENGINEERING WITH NATURE

What is IRIS?

UNIVERSITY OF GEORGIA
Institute for Resilient Infrastructure Systems

- **Institute for Resilient Infrastructure Systems**
- Interdisciplinary community of researchers
- Public-private-academic partnerships
- Co-create infrastructure solutions for more resilient communities and businesses

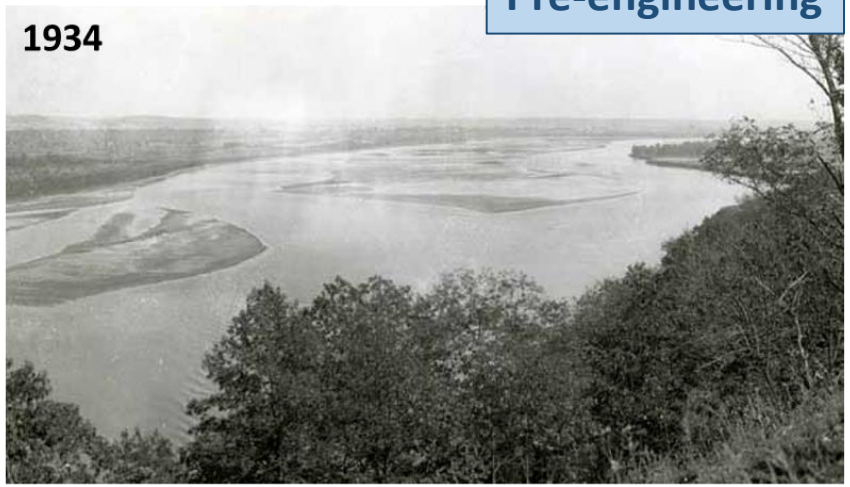
AREAS OF EXPERTISE

- Resilience planning for **multiple hazards**
- **NI** planning, design and evaluation
- **Hydrometeorological** extremes and risks
- **Engineering With Nature®** methodologies
- Hydrodynamic, ecological, and climatological **modeling**
- Military-community resilience
- Risk communication and **landscape visioning** and design
- **Water resources** planning, management and governance
- **Coastal adaptation** planning
- Social and **environmental justice** issues
- **Air quality** assessment and exposure effects
- Regional **sediment management**
- Interdisciplinary **education** and training
- **Ecological engineering** of river, wetland, forest, coastal and urban ecosystems
- **Waste management** and public health
- **Transportation** and **power systems**

Sustainable Levees

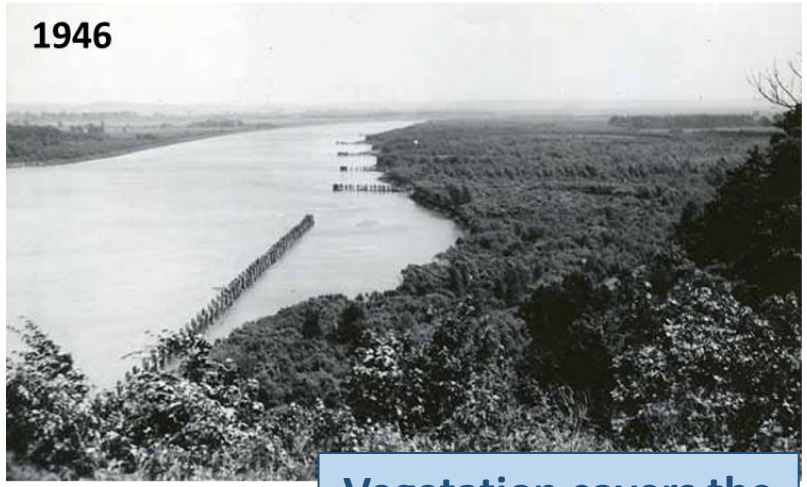
Why Focus on Levees?

- Growing social pressure to change river corridor management practices
  - Freshwater biodiversity crisis
  - FRM, the “levee effect”
- Historical levee engineering practice may be contributing
- Massive number and spatial scales
- Test NbS like levee setbacks
  - Variety of contexts
  - At large spatial scales
  - Broadly meaningful impacts

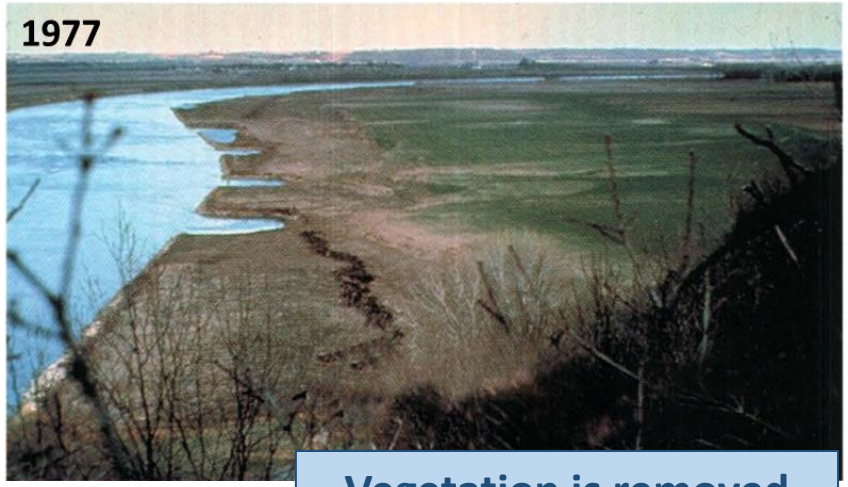


Pre-engineering

Dikes trap sediment, accrete land, and flush the channel



Vegetation covers the accreted floodplain

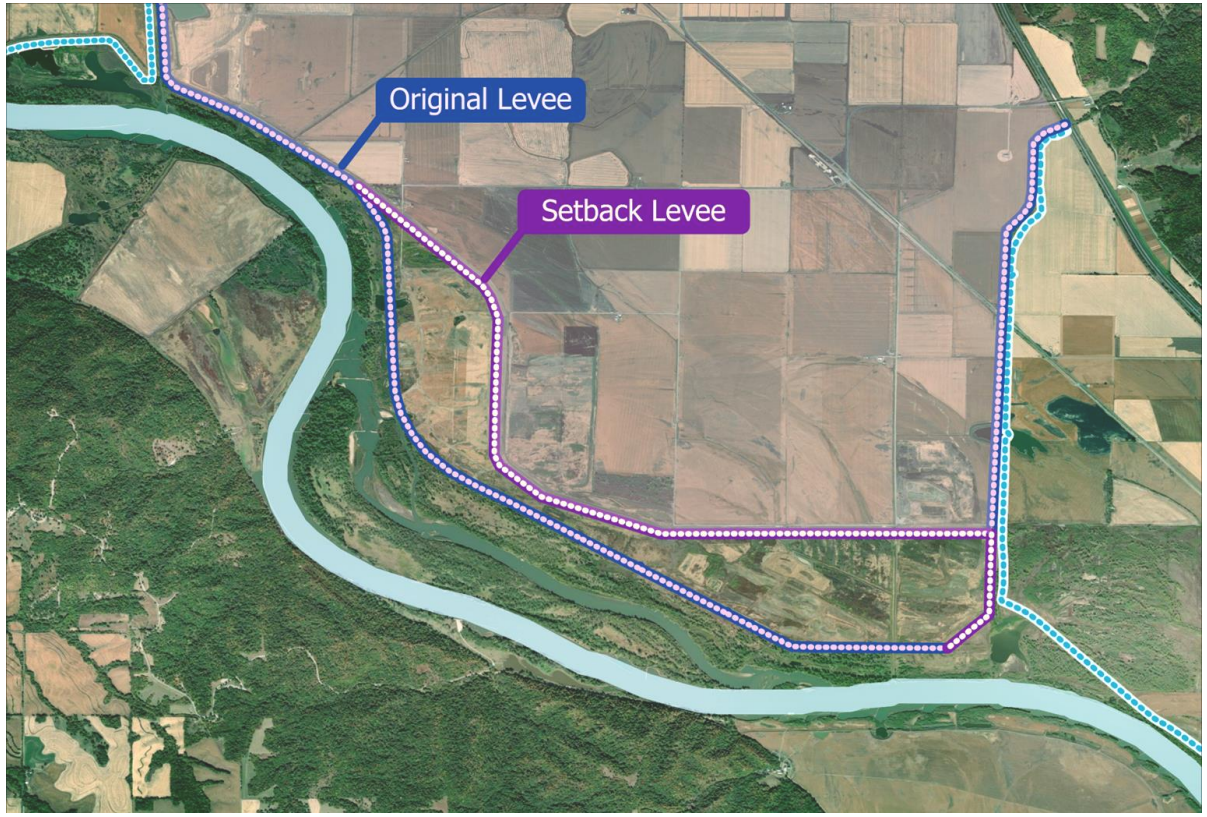


Vegetation is removed for agriculture

Levee construction on accreted land

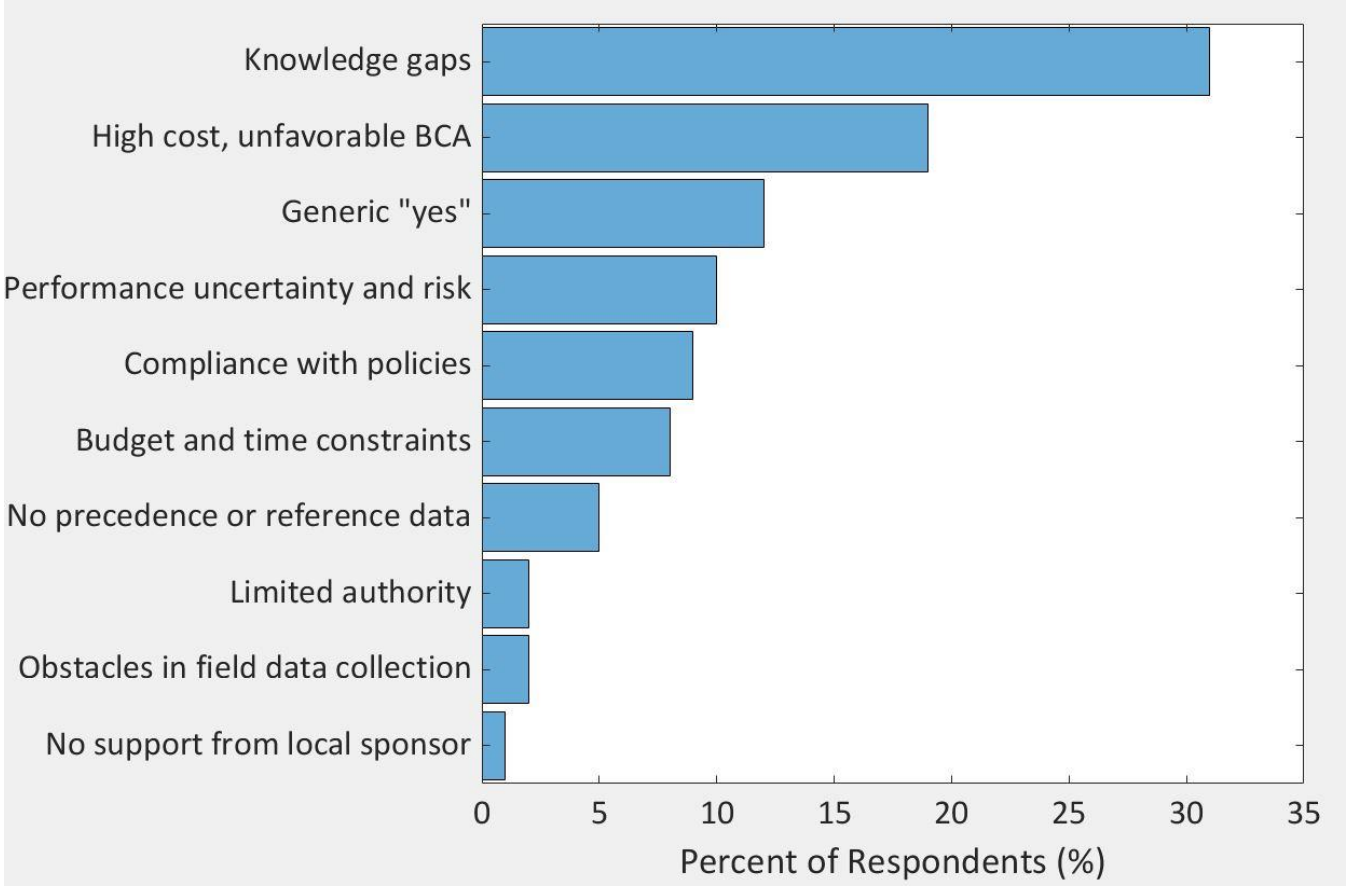
Levee Setbacks

- Setbacks are a NbS
- Floodplain conveyance is a FRM service
  - Reduce the severity of flood hazards
  - Improve LOP and reliability
  - Risk mitigation through relocation
- Alleviate ecological stressors and drivers of biodiversity loss
- Regulation of water quality and climate



What is limiting their application?

- *Outside the obvious…*
  - Expensive
  - Differing land use interests
- *Where there is political will…*
  - Knowledge gaps
  - Uncertain performance
  - Limited guidance
- USACE is embracing NbS, will then implement more setbacks?



Chambers et al., 2023

Collaborative Approach

- Can R&D support civil works planning?
  - Address knowledge gaps and guidance
  - Adoption of new infrastructure approaches
  - Multi-purpose projects
- Translating research to practice
  - Test ideas
  - Accelerate the rate of adoption

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

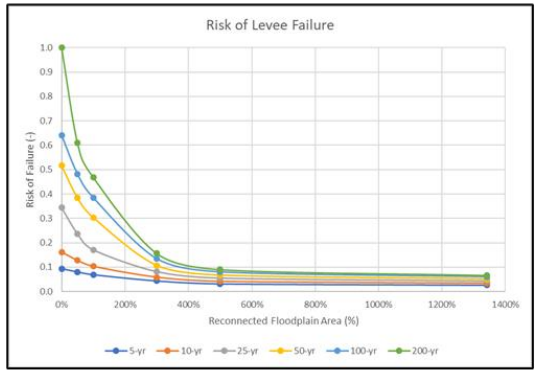
UNIVERSITY OF GEORGIA
Institute for Resilient Infrastructure Systems

NETWORK FOR ENGINEERING WITH NATURE

US Army Corps of Engineers®

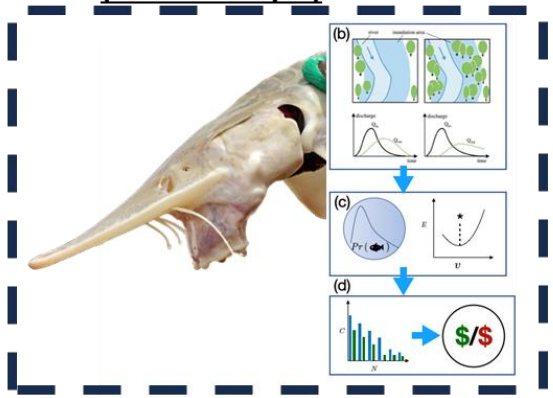
Missouri River Levee Setback Research Program

Levee System Response and Failure Analysis

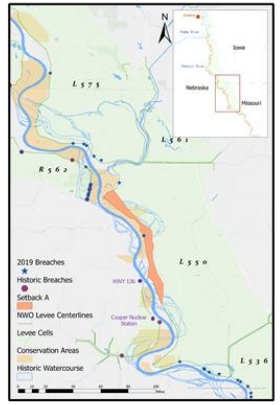


Diffuse Nutrient Mitigation and Borrow Pit Design

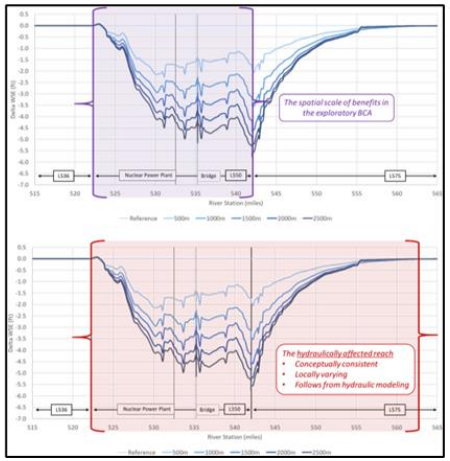
Fisheries Benefits Modeling (not funded yet)



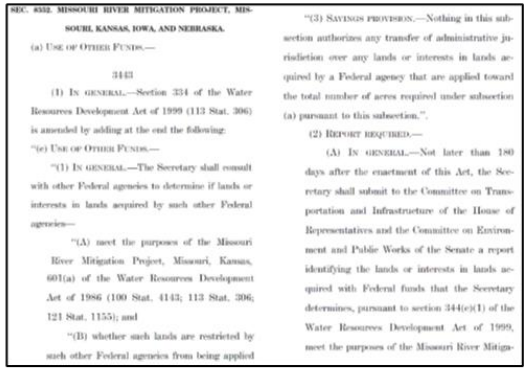
Levee Setback Design



Economic and Experimental Benefit-Cost Analyses



Legal and Policy Analysis of Levee Setback Opportunities and Hurdles



SEC. 8332. MISSOURI RIVER MITIGATION PROJECT, MISSOURI, KANSAS, IOWA, AND NEBRASKA.

(a) USE OF OTHER FUNDS.—

3443

(1) IN GENERAL.—Section 334 of the Water Resources Development Act of 1999 (113 Stat. 306) is amended by adding at the end the following:

"(e) USE OF OTHER FUNDS.—

"(1) IN GENERAL.—The Secretary shall consult with other Federal agencies to determine if lands or interests in lands acquired by such other Federal agencies—

"(A) meet the purposes of the Missouri River Mitigation Project, Missouri, Kansas, 601(a) of the Water Resources Development Act of 1986 (100 Stat. 4143; 113 Stat. 306; 121 Stat. 1155); and

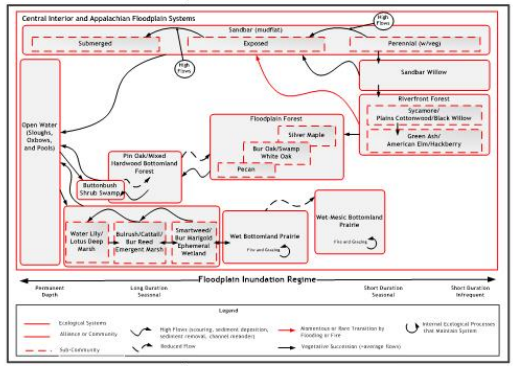
"(B) whether such lands are restricted by such other Federal agencies from being applied

"(3) SAVINGS PROVISION.—Nothing in this subsection authorizes any transfer of administrative jurisdiction over any lands or interests in lands acquired by a Federal agency that are applied toward the total number of acres required under subsection (a) pursuant to this subsection.".

(2) REPORT REQUIRED.—

(A) IN GENERAL.—Not later than 180 days after the enactment of this Act, the Secretary shall submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate a report identifying the lands or interests in lands acquired with Federal funds that the Secretary determines, pursuant to section 344(e)(1) of the Water Resources Development Act of 1999, meet the purposes of the Missouri River Mitiga-

Biodiversity Benefits of Large-scale Levee Setback

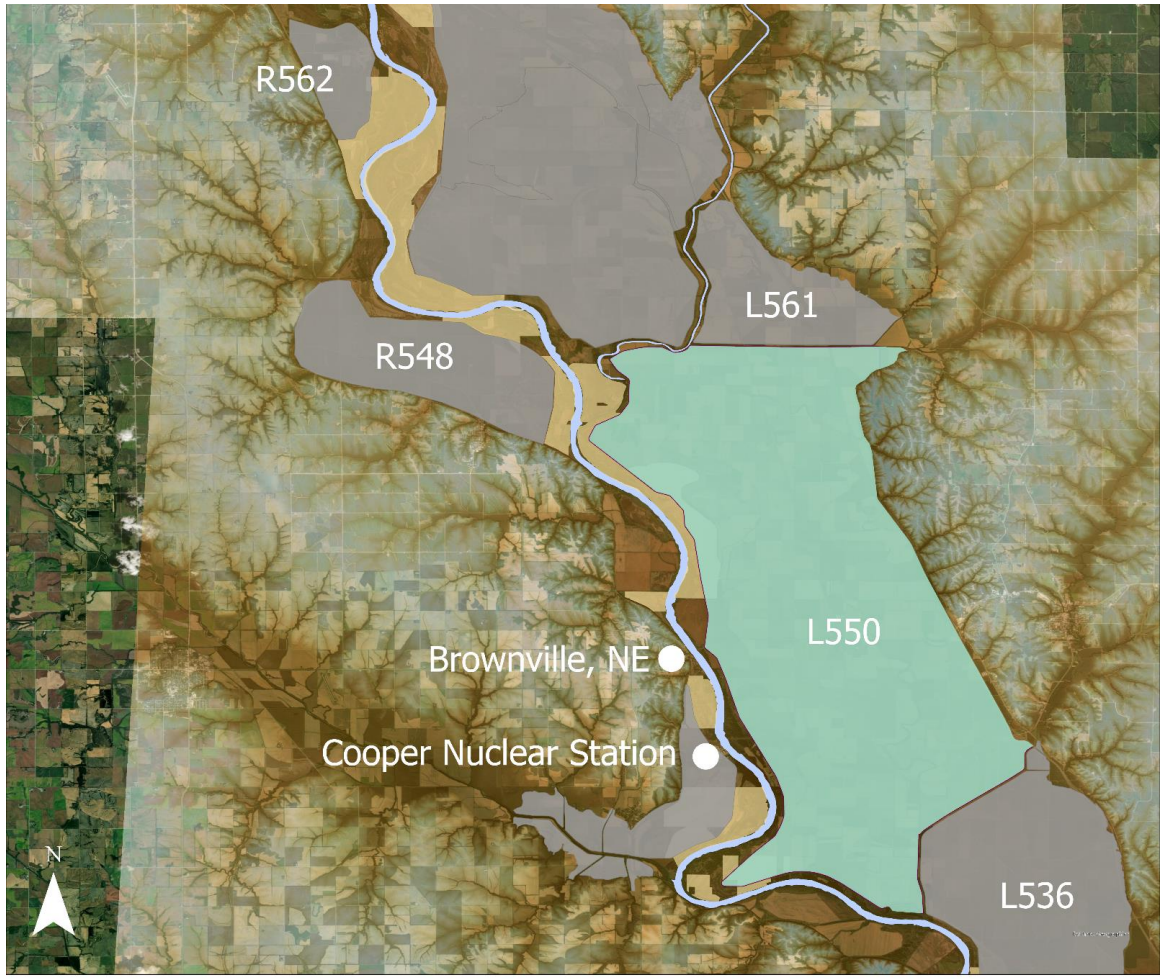


Socio-economic Assessment and Perception Surveys (not funded yet)

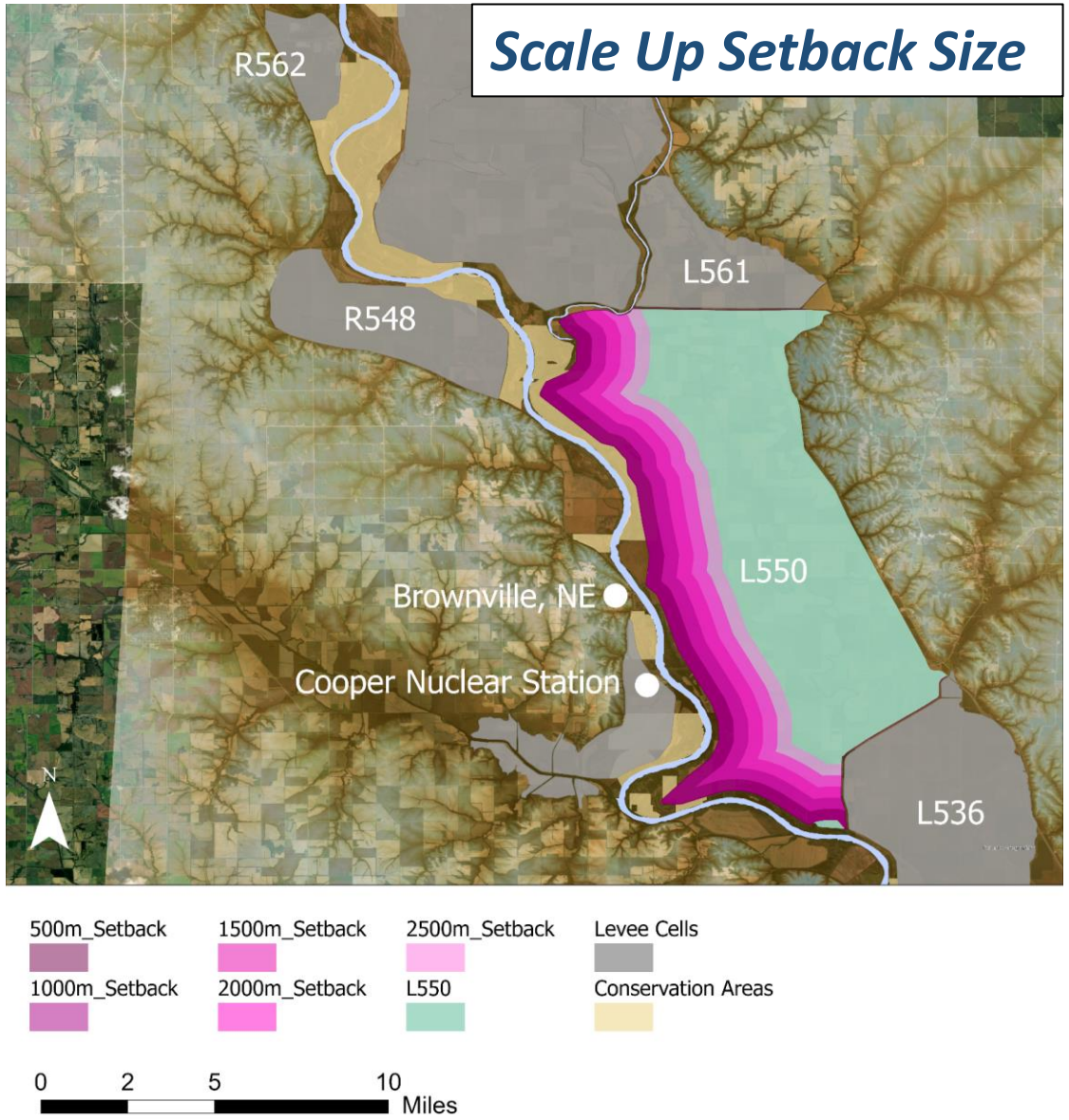
Tribal Engagement and Equity (not funded yet)

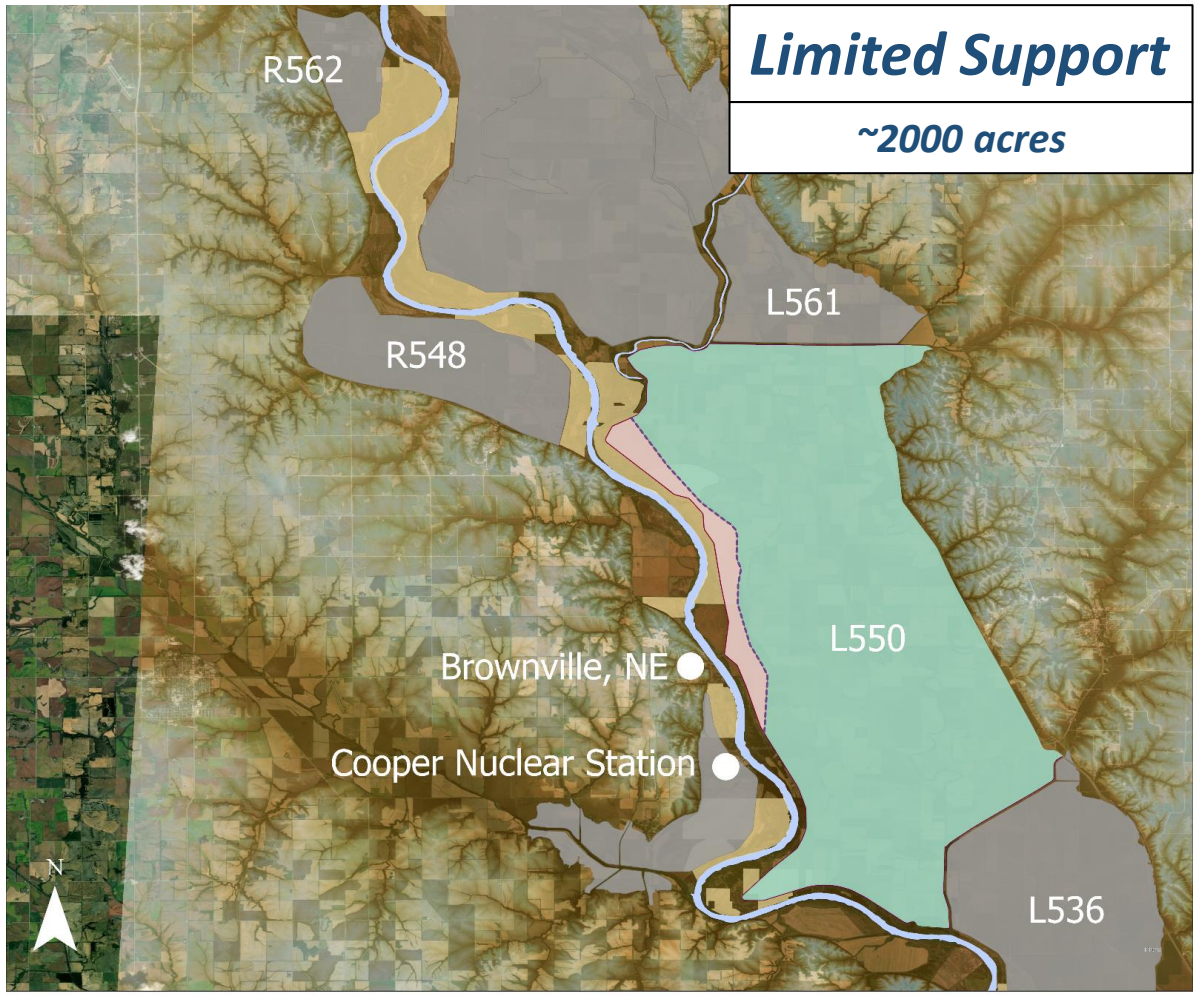
Levee L550

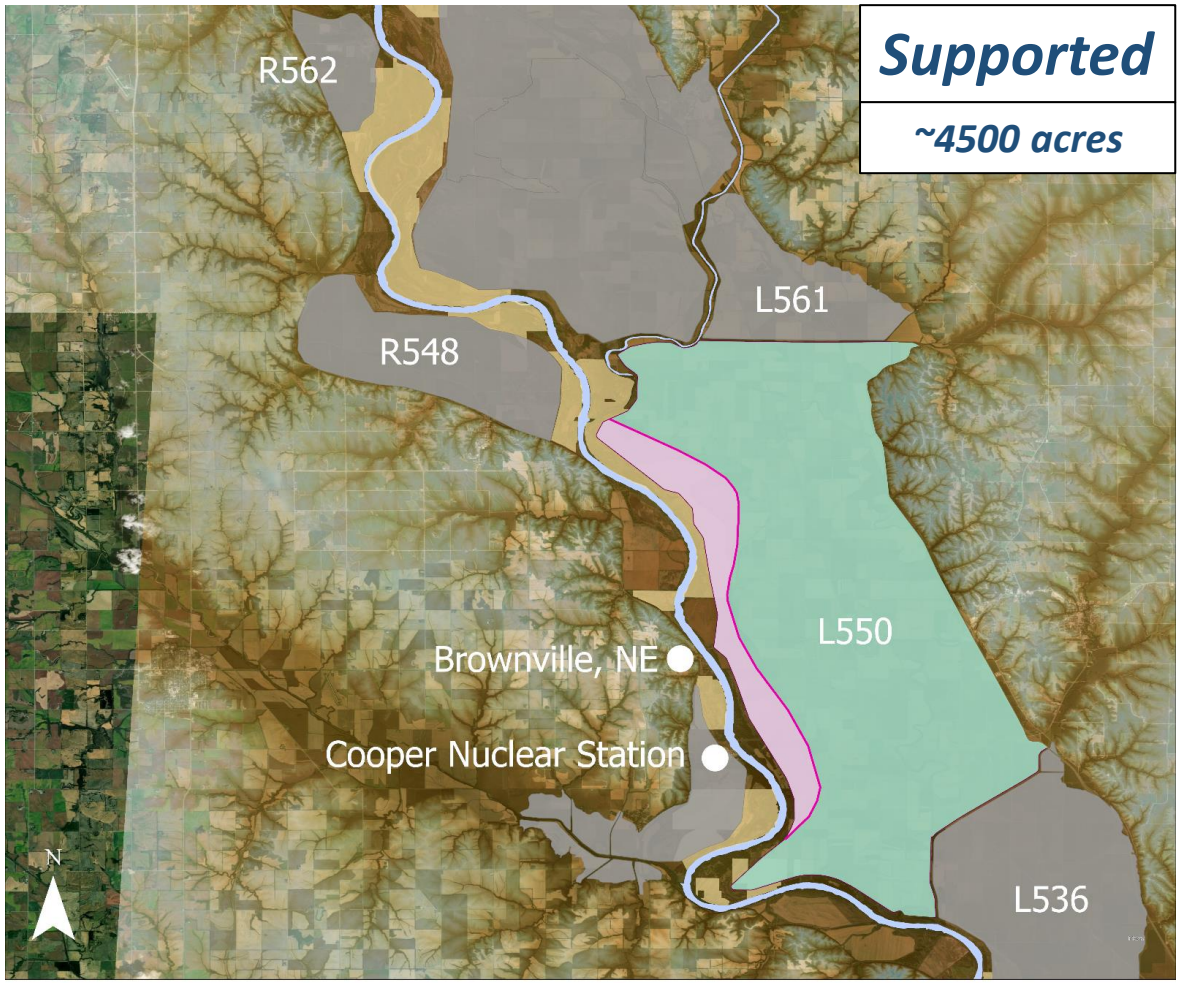
- ~40k acres, ~22 miles of frontage
- History of repeated failures with in-line repairs under PL 84-99
- Recent setbacks at upstream and downstream levee cells
- Test bed for modeling benefits



Scale Up Setback Size




Limited Support
~2000 acres
R562
L561
R548
L550
Brownville, NE
Cooper Nuclear Station
L536
N
Setback A
L550
Levee Cells
Conservation Areas
0 2 5 10
Miles


Supported
~4500 acres
R562
L561
R548
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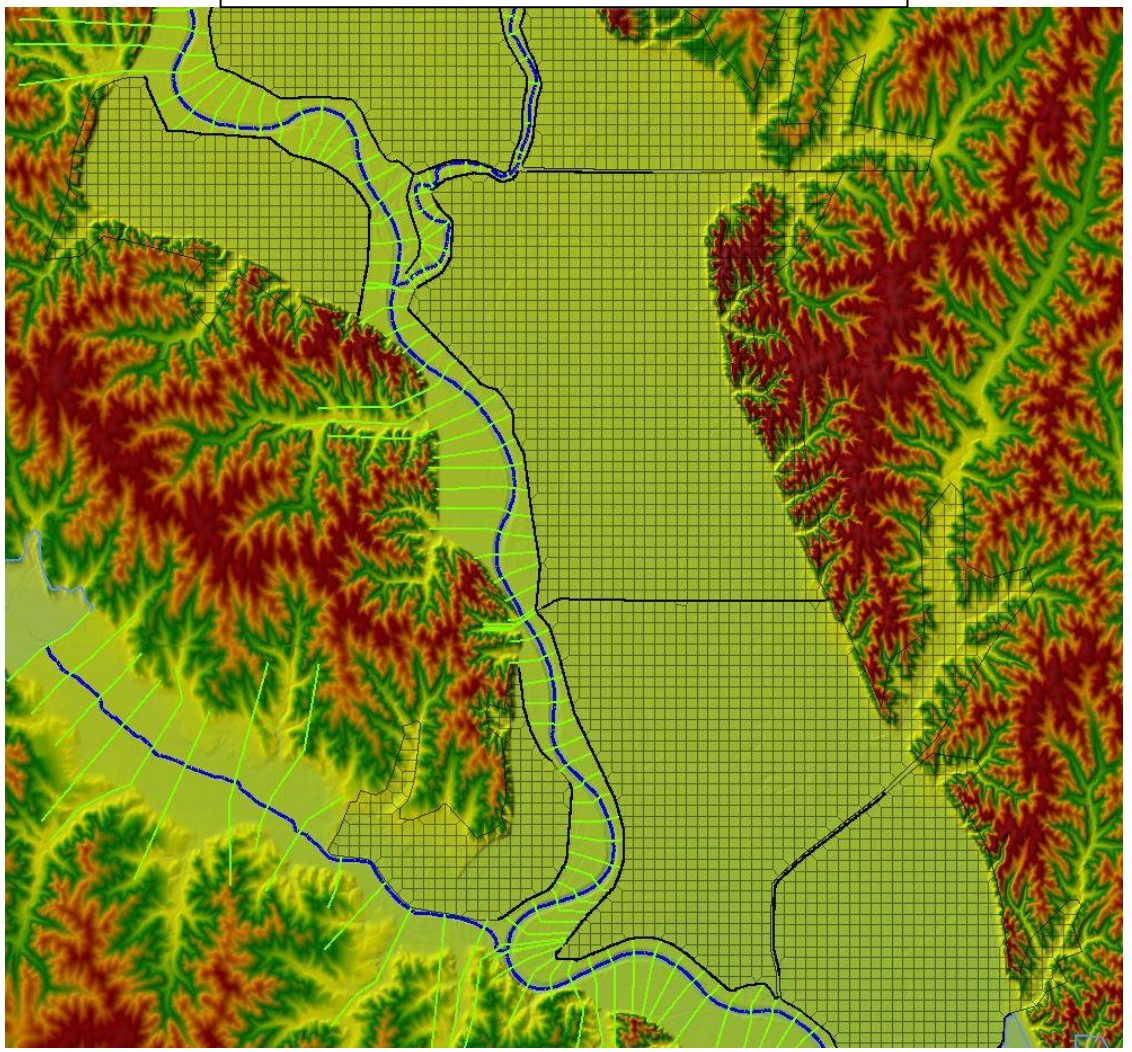
L536
N
Setback E
L550
Levee Cells
Conservation Areas
0 2 5 10
Miles

Example Research Projects

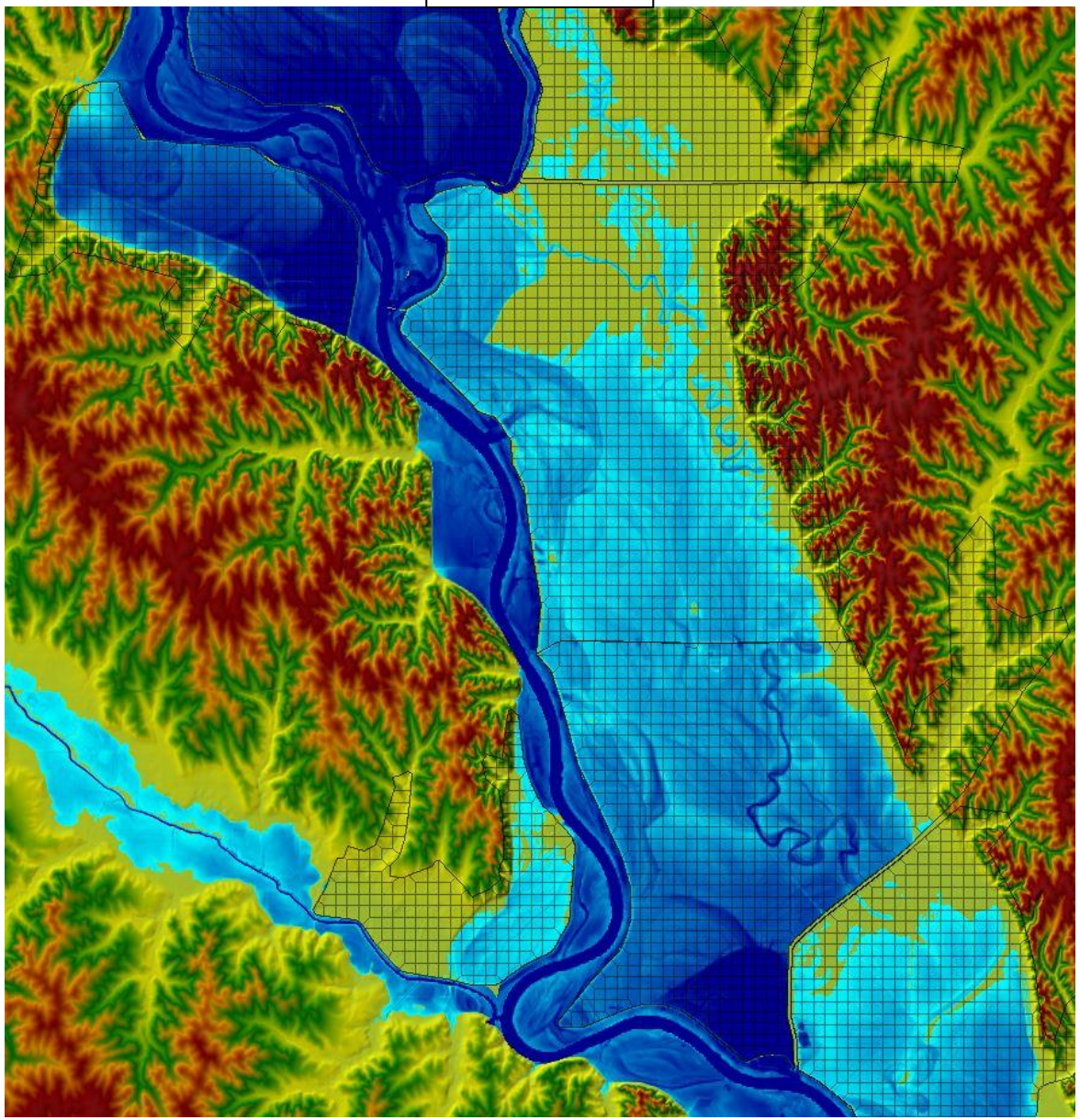
Flood Risk Management

- Model setback performance
- Communicate risk and hazard reductions
- Design and modeling guidance
- USACE numerical hydraulic models
  - 1D/2D Unsteady
  - 2D floodplain reconnections
  - Intermediate complexity

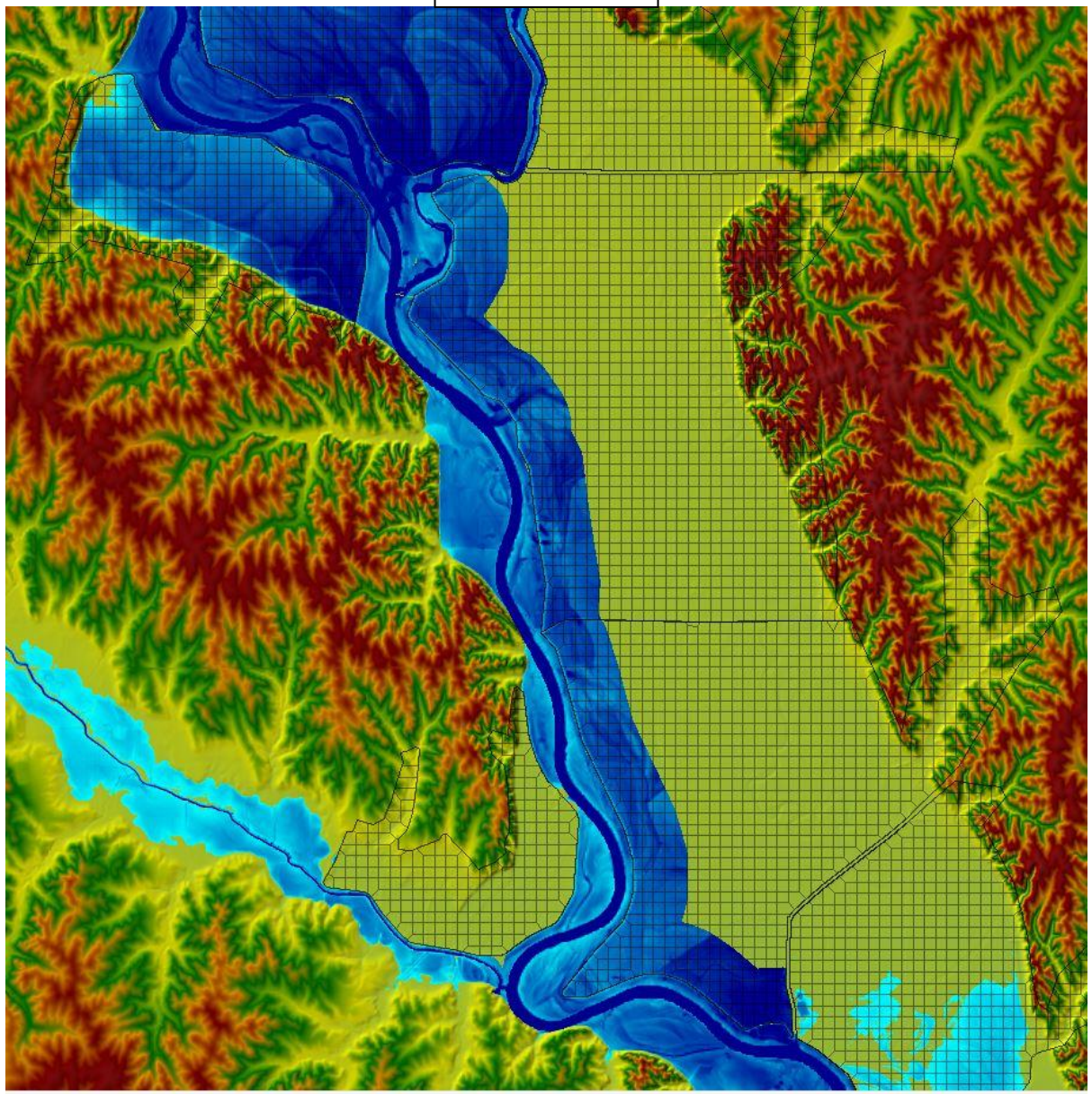
Modified USACE HEC-RAS Model



Existing

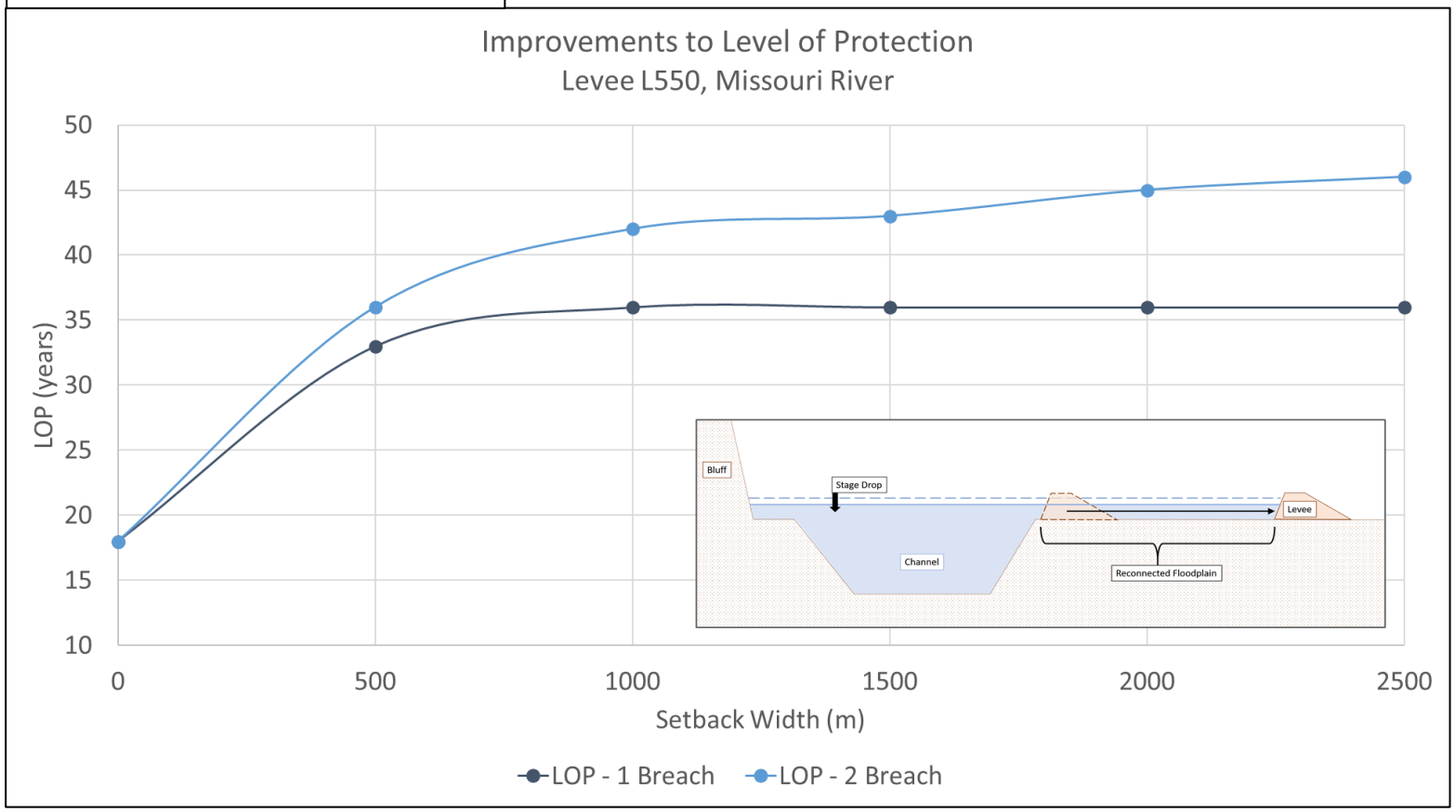


Setback

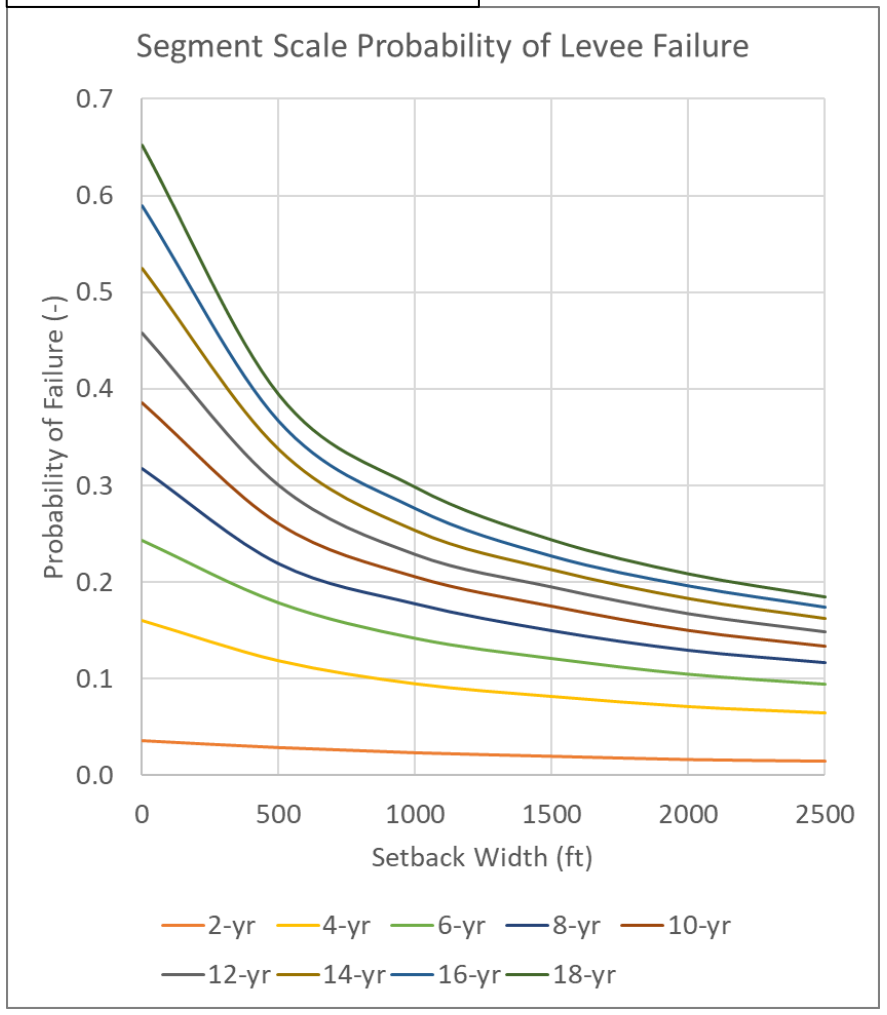


Performance

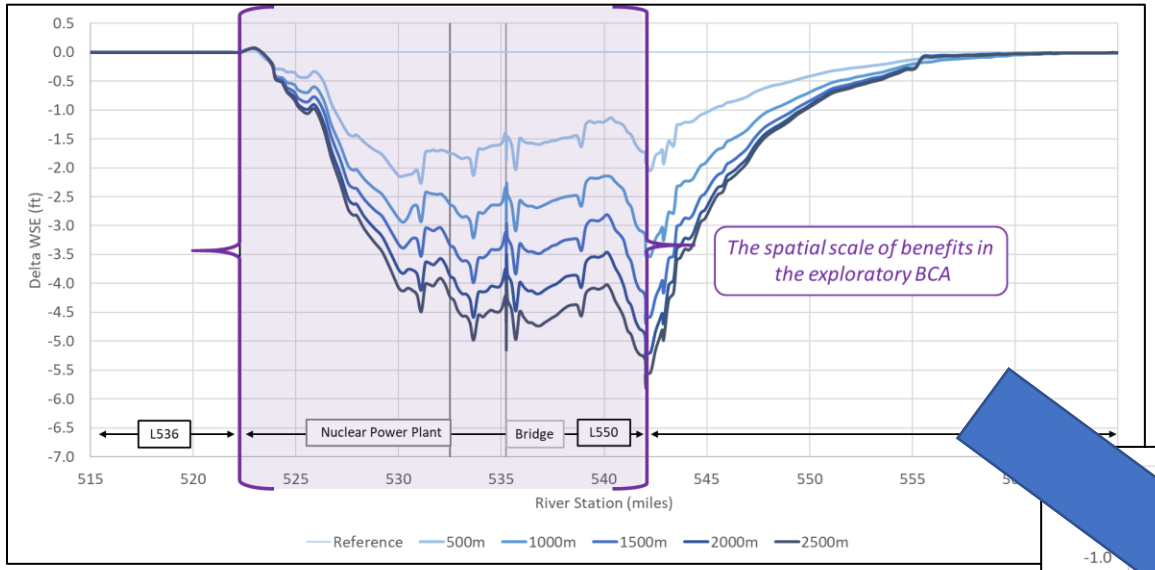
Level of Protection



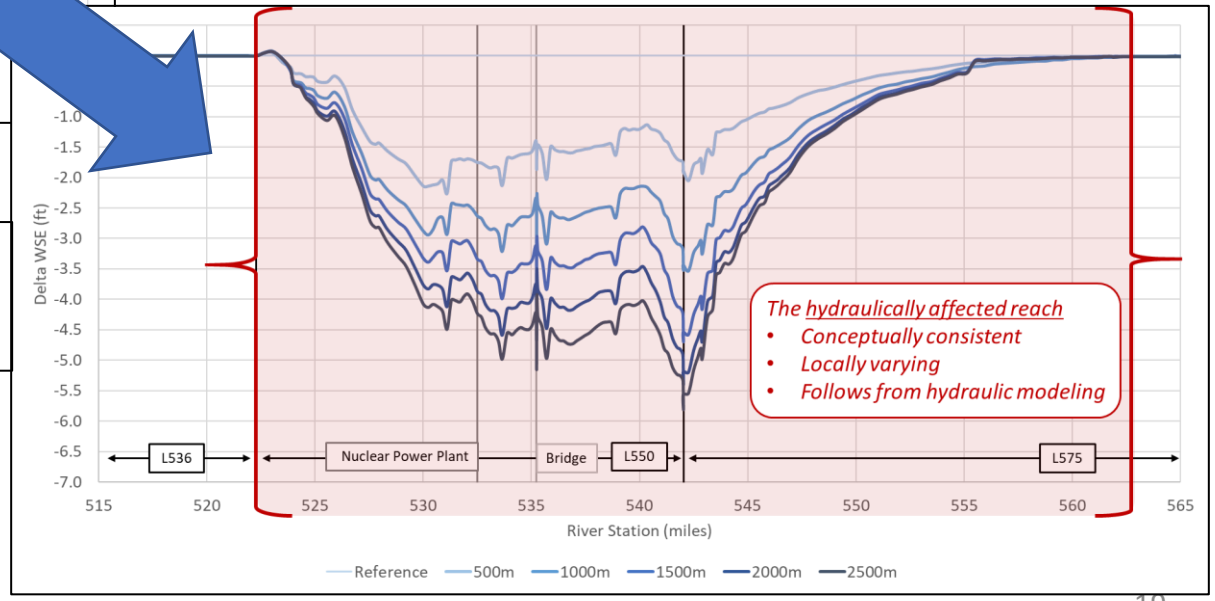
Levee Reliability



Define the Spatial Scale of Benefits

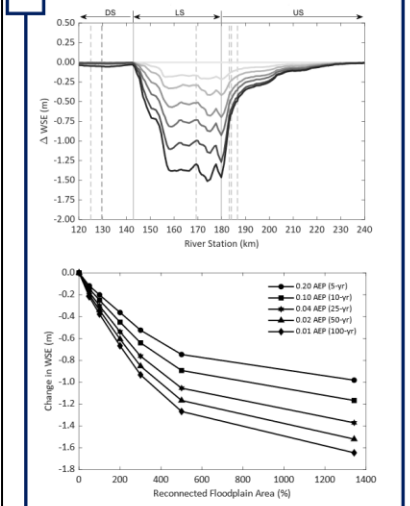


Use the hydraulics to quickly and repeatability define the spatial scale of benefits transfer…

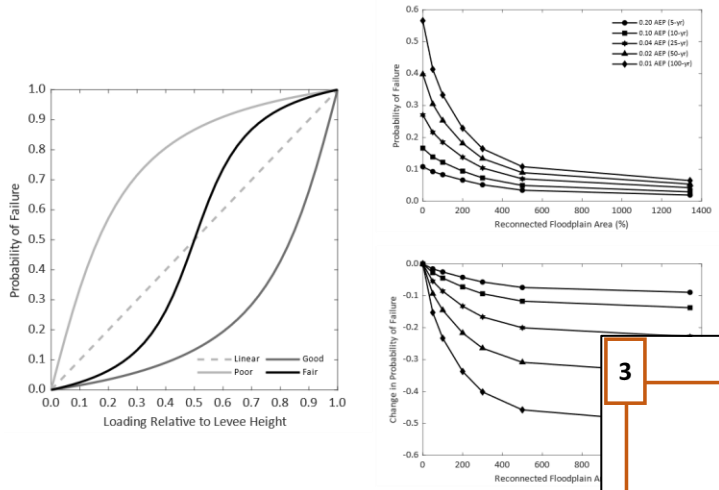


Draft Guidance on How to Size a Setback

1 Model Hazard Mitigation

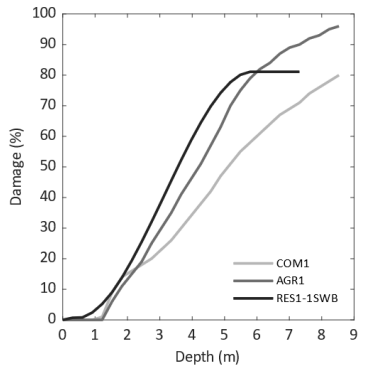


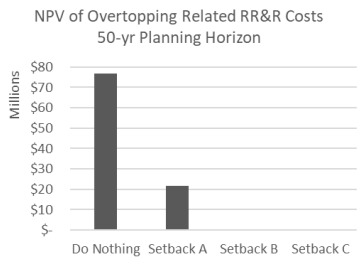
2 Quantify Risk Mitigation

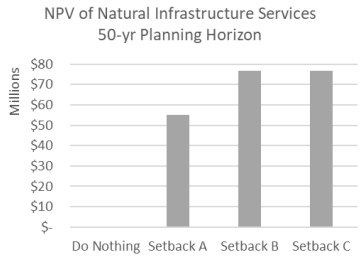


Sizing based on flood loss mitigation from improved reliability and level of protection

3 Quantify Expected Flood Losses Mitigated







4 Plug into BCA

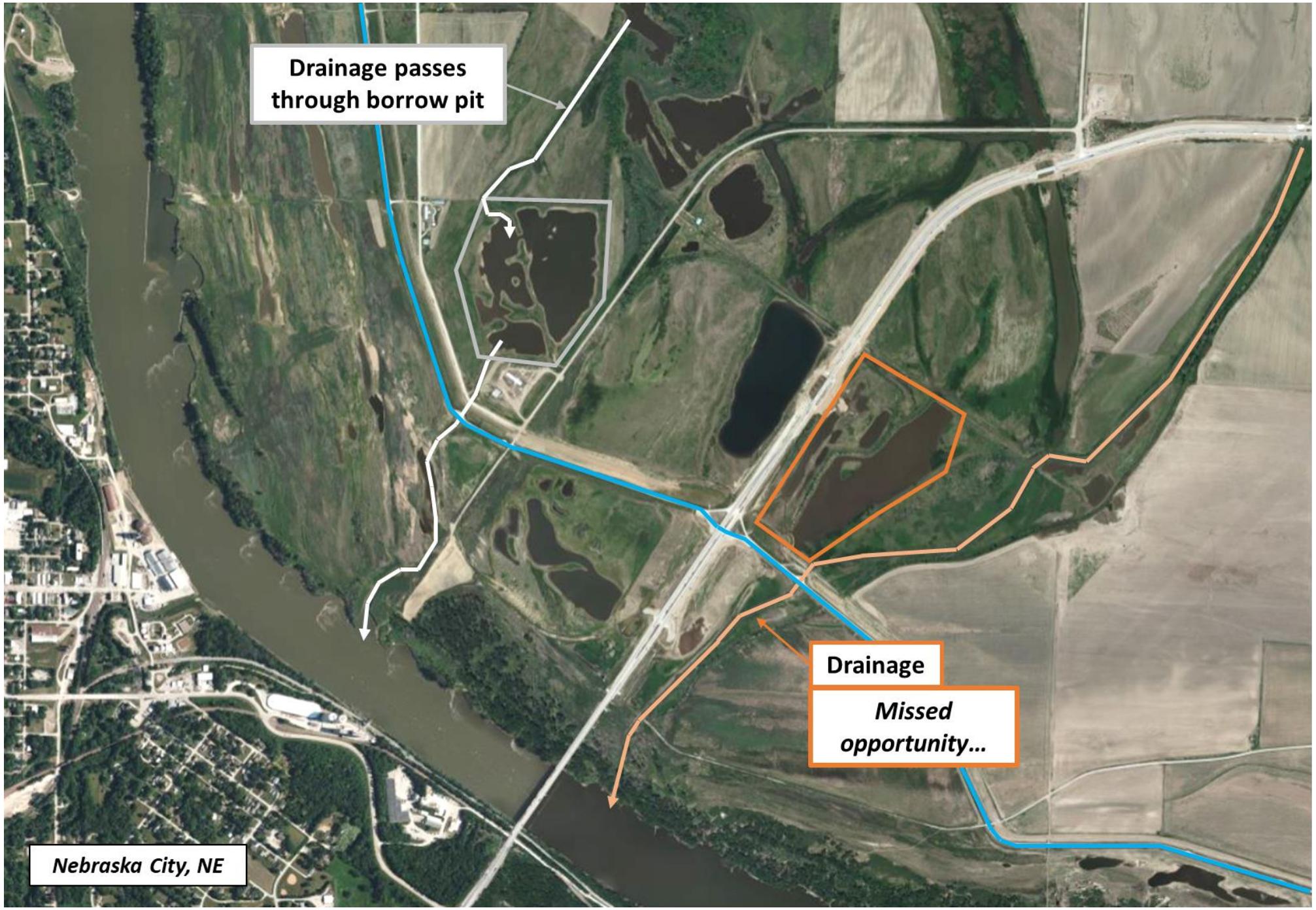
- Sum expected benefits and costs over the planning horizon
- For the full range of flood conditions
- Based on conditional probabilities of occurrence within the hydraulically affected reach
- Discounted to NPV or annualized

$$ED_t = \sum_i^n \left(\sum_j^m P_j D_j \right) \Delta ACE_i$$

$$NPV = \sum_t^T \frac{ED_t}{(1+r)^t}$$

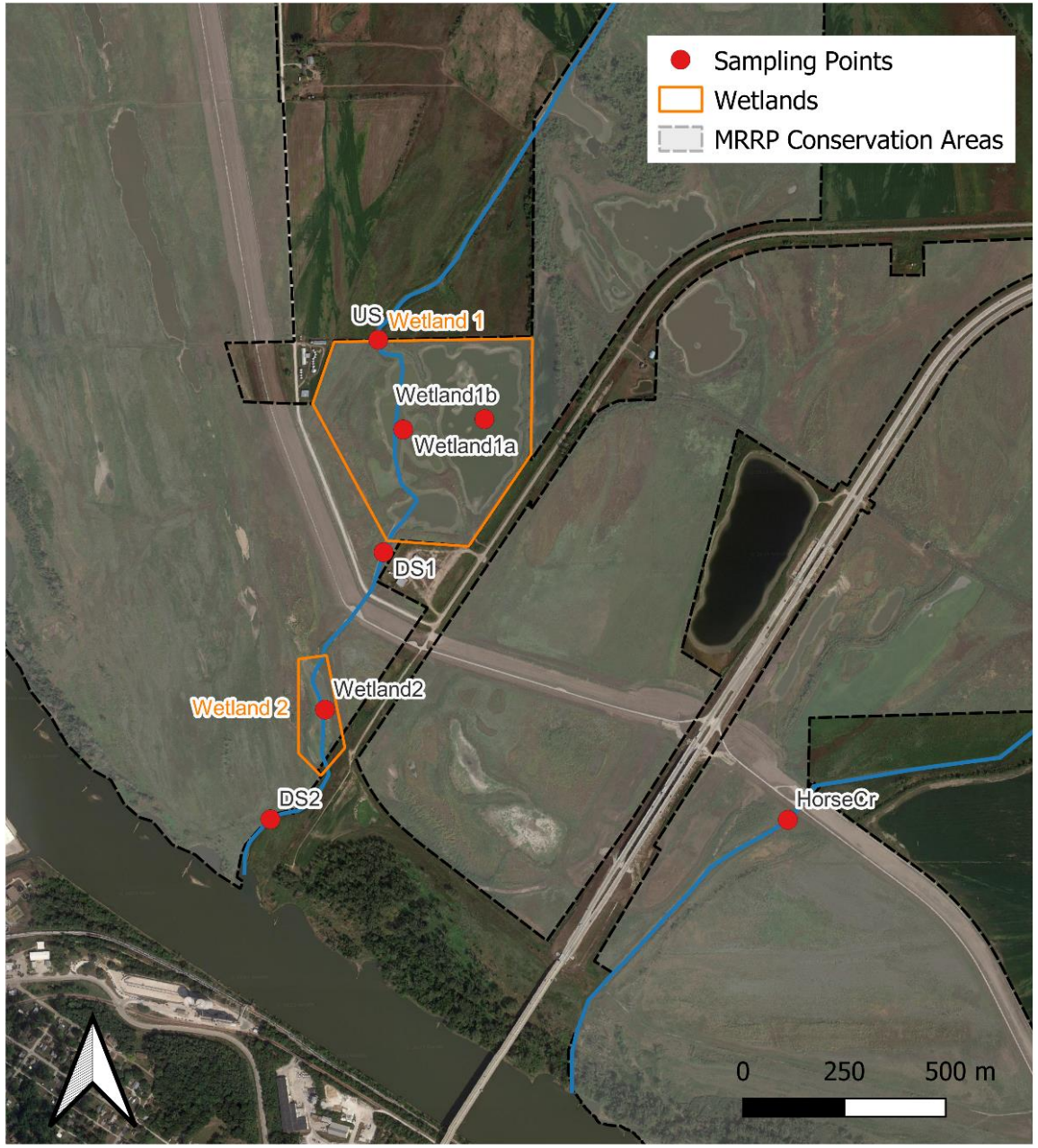
Water Quality

- Downstream WQ benefits
  - Potential to reduce nutrient loading?
  - Large rivers with high nutrient loading?
  - Spatial scale of one setback?
  - Material impact on BCR?
- Parallel approach
  - Engineer borrow pit treatment wetlands
  - Re-plumb agriculture drainage to retain excess nutrients
  - Affordable? Practical? Effective?


Drainage passes through borrow pit
Drainage
Missed opportunity…
Nebraska City, NE

Water Quality

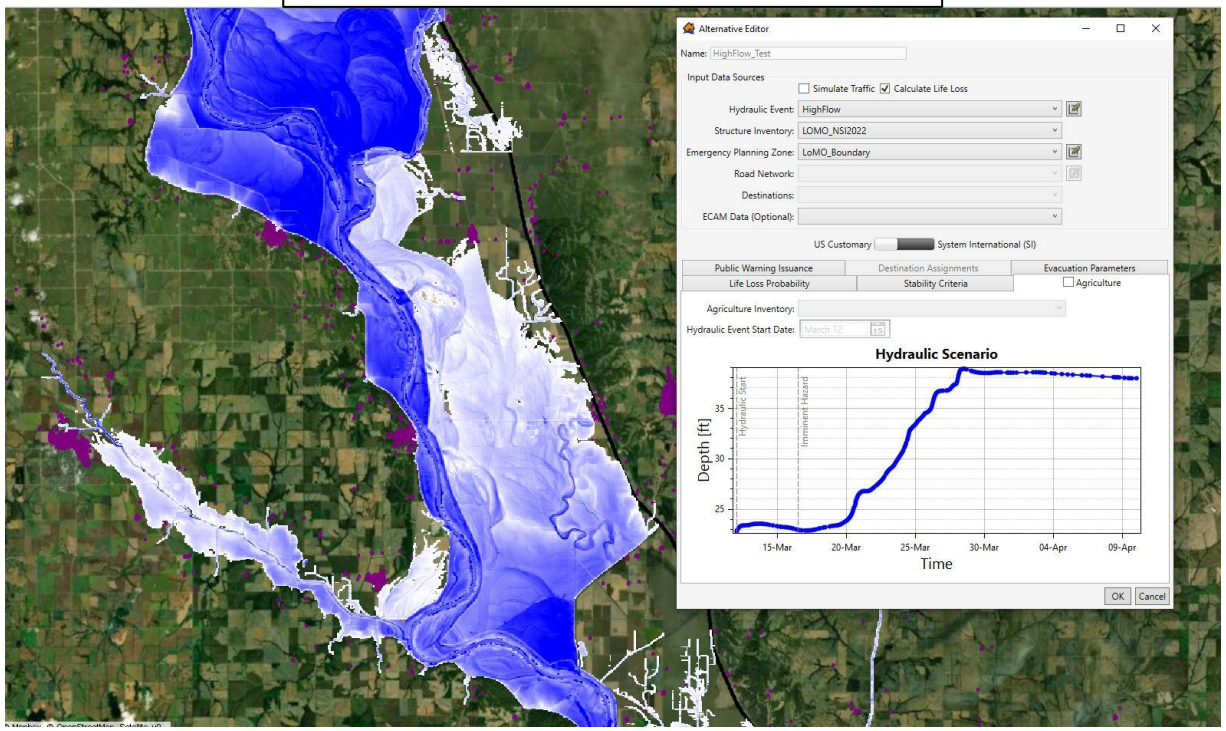
- Can we collect sufficient data to inform numerical modeling?
- Despite limited site selection and experimental design
- Use numerical modeling to inform design and guidance
  - e.g., residence time, vegetation
  - e.g., design service
- Test modeling recommendations at other borrow pits
- Draft guidance



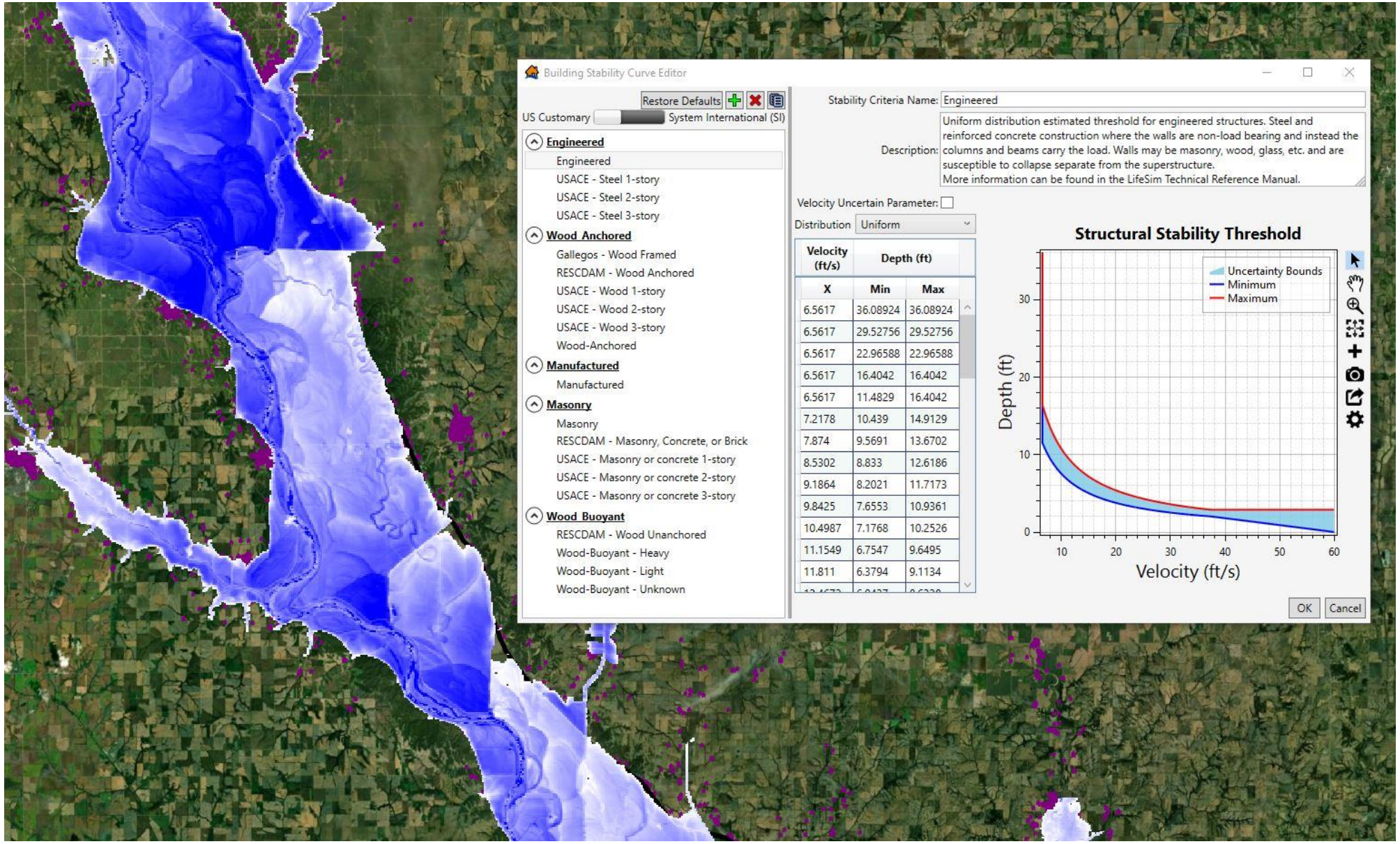
Experimental Benefit-Cost Analysis

- Understand and then improve upon existing methods
- Comprehensive accounting of benefits and costs
- Seek approval for benefits quantification methods
  - e.g., method for defining spatial scale of benefits transfer in FRM
  - Simple and repeatable
  - Intermediate complexity
  - Integrate with existing BCA process

Modified USACE LifeSim Model



How to modify USACE LifeSim models for greater accuracy and diversity of benefits?




Thank you!